7340-EN-01
DTIC

REVIEW OF EUROPEAN LITERATURE ON WETLAND SOIL AND BIOLOGICAL PROCESSES

Dr. Martin C.Th. Scholten
N. (Klaas) H.B.M. Kaag
TNO Environmental Sciences
Den Helder, The Netherlands

REVIEW OF EUROPEAN LITERATURE ON WETLAND SOIL AND BIOLOGICAL PROCESSES

Final Report

March 1995

by

Dr. Martin C.Th. Scholten

N. (Klaas) H.B.M. Kaag

TNO Environmental Sciences

Den Helder, The Netherlands

CONTRACT NUMBER: N68171-94-C-9083

United States Army

EUROPEAN RESEARCH OFFICE

London, England

ABSTRACT

The project aims at the documentation and synthesis of a compilation of European literature on wetland soil and biological processes, complementary to a review of American literature by WES. In total, 317 appropriate publications have been selected, and recorded in a database according to the WES "Matrix of Information on Critical Wetland Soil, Vegetation and Biological Processes". All records are characterized with some remarks. Most of the records deal with nutrient (C, N, P, S) cycling and tolerances of plants to wetland soil conditions (viz. low redox potentials and salinity). A synoptic overview of the main processes described in the selected papers, as well as the methods used to study these processes, is presented in a number of paragraphs. To each paragraph a short reference list is added.

The complete references are given in the Appendix, included in this report.

KEYWORDS

wetlands, nitrification, denitrification, sulphide, redox-potential, anoxia, decomposition, nutrient cycling, phosphate, metals, Fe, Me, CO_2, methane, detritus, salinity, organic matter, soil aeration, vegetation, synopsis, tolerance.

ACKNOWLEDGEMENTS

The Principal Investigator of the project is Dr. Martin C.Th. Scholten. He is the head of the Laboratory for Field Ecology of the TNO Institute of Environmental Sciences. He studied wetland ecology at the Free University of Amsterdam.

Other scientists working on the project, under supervision of the P.I., were:
N.(Klaas) H.B.M. Kaag (main assistant), Henno P. van Dokkum, Robbert G. Jak, Chris C. Karman and Henk P.M. Schobben. All these scientists have a University degree on wetland ecology and work at the TNO Laboratory for Field Ecology.

TABLE OF CONTENTS

1. INTRODUCTION

1.1 Background and objective

The US Army Corps of Engineers Waterways Experiment Station (WES), Environmental Laboratory, runs a Wetland Research Project aimed at defining and quantifying wetland functions as a part of wetland management. One of its objectives is to review available literature on critical wetland soil and biological processes.

The aim of this report is to collate European literature on wetland soil and biological processes in a format complementary to a review of American literature by WES.

1.2 American-European antithesis

An important factor to be acknowledged in this project, is the different usage of the term "wetlands" in America and Europe. In America "wetlands" is a common denominator for all kinds of wet (but not permanently submersed) ecotones with (temporarily) water saturated soils and hydrophyte vegetation. In Europe, these ecotones are referred to as "floodplains" "swamps", "marshes", "fens" and "bogs" (Gore, 1983; Gopal *et al.*, 1990). Only recently, the term "wetlands" is being more commonly used in Europe, in a much broader context associated with waterfowl sanctuaries (according to the definitions of the Ramsar Wetland Convention; UCN, 1971). In this context, the term "wetlands" refers to the complexity of ecotones in an entire nature conservation area, and thus also includes shallow (permanently submersed) lakes or coastal waters as well as flooded meadows (without a real hydrophyte vegetation).

As a consequence, there exists a difference between American and European wetland ecologists regarding their main focus of interest. American wetland ecologists are primarily concerned with soil processes (hydrological, geochemical, microbiological) and related

biological processes (productivity and succession), whereas European wetland ecologists are primarily interested in the functioning of wetlands as habitat for sensitive and/or rare species (active biological management and population biology, i.e. strategies of wetland flora and fauna for coping with wetland conditions and interactions amongst wetland biota).

European wetland research is primarily directed by the fact that the wetland area is strongly decreasing due to drainage (in order to promote arable landuse, viz. marshes and fens in NW Europe), canalization of rivers (viz. floodplains at the margins of central Europe), creation of reservoirs (Central Europe), development of tourist industry (marsh areas in Southern Europe) and heavy pollution (Eastern Europe).

To ensure that the review of the European literature is actually complementary to the review of the American literature, it was decided to use the American mode as a premise for the documentation of the European literature. The American introductory text book on wetlands by Mitsch & Gosselink (1986) is used for terms of reference, while the available literature is organized according to the "Matrix of Information on Critical Wetland Soil, Vegetation and Biological Processes" developed by WES. As a consequence, not all available European literature on wetland ecology is applicable in this review of wetland soil and biological processes.

1.3 Matrix of Information

The “Matrix of Information on Critical Wetland Soil, Vegetation and Biological Processes” consists of a list of processes, subdivided into four categories referring to laboratory studies, field studies, computerized studies or descriptive studies. The “Matrix” has been extended with two categories to enable classification of significant European literature on wetland ecology: tolerances of wetland flora and fauna to wetland soil conditions (see section 4.8) and general management of wetland habitat areas (see section 5.4). The complete design of the “Matrix of Information” used to categorize literature records is given in Figure 1.

Process	Descr.	Lab	Field	Comp.	Process	Descr.	Lab	Field	Comp.
N-Transformations					**Emergent Vegetation**				
Denitrification					**Uptake and Cycling**				
Nitrification					*Nitrogen*				
NH_3 Volatilization					*Phosphorus*				
Ammonification					*Potassium*				
S-Transformations					*Metals*				
Sulfide/Sulfate					*Organics*				
Hydrogen Sulfide					**Rooting**				
C-Transformations					*Substrate Modification*				
Methane production					*Aeration*				
CO_2 production					*Substance Excretion*				
Org. Material Accumulation					*Detritus Production*				
P-Transformations					*Filtering Water*				
Soluble P									
Exchangeable P					**Algae**				
Total P					**Uptake and Cycling**				
P Cycling					*Nitrogen*				
Fe-Transformations					*Phosphorus*				
Ferrous Iron					*Potassium*				
Soil color					*Metals*				
Mn-Transformations					*Organics*				
Manganous Mn					**Sediment**				
Metal Transformations					*Substrate Modification*				
Sediment/Water Exchange					*Aeration*				
Redox Potential					*Substance Excretion*				
Soil Oxygen					*Detritus Production*				
					Filtering Water				
Sedimentation									
Permeability					**Microbial**				
Vertical									
Lateral					**Bioturbation**				
Consolidation					*Sediment Dwellers*				
Compaction					*Surface Dwellers*				
Tolerances					**Freezing/Ice Effects**				
Saltmarsh Flora					**Heat Effects**				
Reedswamp Flora					**Drought Effects**				
Fen/Bog Flora									
Floodplain Flora					**Vegetative Succession**				
Wetland Fauna									
					Habitat management				

Figure 1: Matrix of Information on Critical Wetland Soil, Vegetation and Biological Processes (after Lee, USAE-WES, pers. comm.): A listing of processes (main processes in bold, subprocesses in italics) and the categories referring to the type of information (descriptive, lab methods, field methods, computer methods).

1.4 Work procedure

Some 2000 publications (papers, reports, theses, books) adressing to "wetland ecology" in its broadest context have been screened for this review. Those publications related to any one of the wetland processes mentioned in the extended "Matrix of Information", and with a first author affiliated to a European research organization, have been selected for the European compilation. Publications dealing with the benthic part of shallow lakes or coastal waters and with inundation of flooded meadows were included in this selection. In total, 317 appropriate publications have been selected. All literature is archived in the bibliographic system "TNOLIT" of the TNO Laboratory for Ecological Research and is available upon request. Most of the wetland references not selected for this compilation deal with studies on bird and other wildlife, description of flora and fauna, vegetation processes (viz. competition), and management works.

The selected literature references are recorded in a specially developed database, using a structure simular to the outline of the extended "Matrix of Information". The database enables an easy and rapid selection of records for process categories distinguished in the "Matrix of Information". Moreover, it gives opportunities to print out lists of (selected) references and tables representing a part of the "Matrix of Information". A data sheet assists easy entry of new records.

To all selected records an identification number and complete reference have been attributed. In addition, all records are characterized by a country code (affiliation of first author), the applicable positions in the "Matrix of Information" and some remarks (summary statements, conclusions, characteristics, remarkable facts etc.).

The records are listed in Appendix I (references and remarks), while their position in the "Matrix of Information" is indicated in chapters 2 to 5 (see section 1.6 for an outline of the report).

The categories of studies, distinguished in the "Matrix of Information", have been defined as follows:

Field: field surveys, *in situ* measurements in the field or analysis of field samples

Lab: experimental studies (including outdoor mesocosm and greenhouse) and *in vitro* measurements on materials collected from the field and incubated under controlled, experimental conditions

Computer: mathematical modelling and (mass)balance calculations

Description: papers not dealing with one of the three other categories (field, lab, computer). This means that a record categorized under "description" does not refer to any of the other categories for a single process. Most of these papers are reviews.

This latter strategy has also been applied to the categorization of records under headings referring to a class of processes (e.g. "N-transformations"), when the record is not categorized under one of the single processes (in this case "nitrification", "denitrification", "NH_3-volatilization", "ammonification").

1.5 General statistics

About 60% of the records are related to papers published in scientific journals. Another 35% of the records ar related to papers/chapters published in scientific books or conference proceedings. The remainder 5% is related to technical reports and Ph.D theses (all of Dutch origin).

Most of the selected wetland literature originates from a few Northwest European countries (Figure 2): The Netherlands (102 records), Great Britain (55 records), Sweden (53 records), Germany (25 records), Denmark (21 records) and Finland (19 records). This partly reflects the distribution of main wetland areas in Europe (Dugan, 1993). Ireland is the only country

from this wetland region with remarkably few publications on wetland studies. The Northeastern part of Europe (Poland, Russia and Baltic states) is, however, an even more important wetland region. Although it is known that a lot of wetland studies are performed in these countries, literature is still not easy available. Moreover, participation of researchers from Eastern Europe in scientific networks is still limited despite the many conferences organized after the changed political situation. There are only few small wetland areas left in Central and Southern Europe, explaining the low numbers of records from these regions.

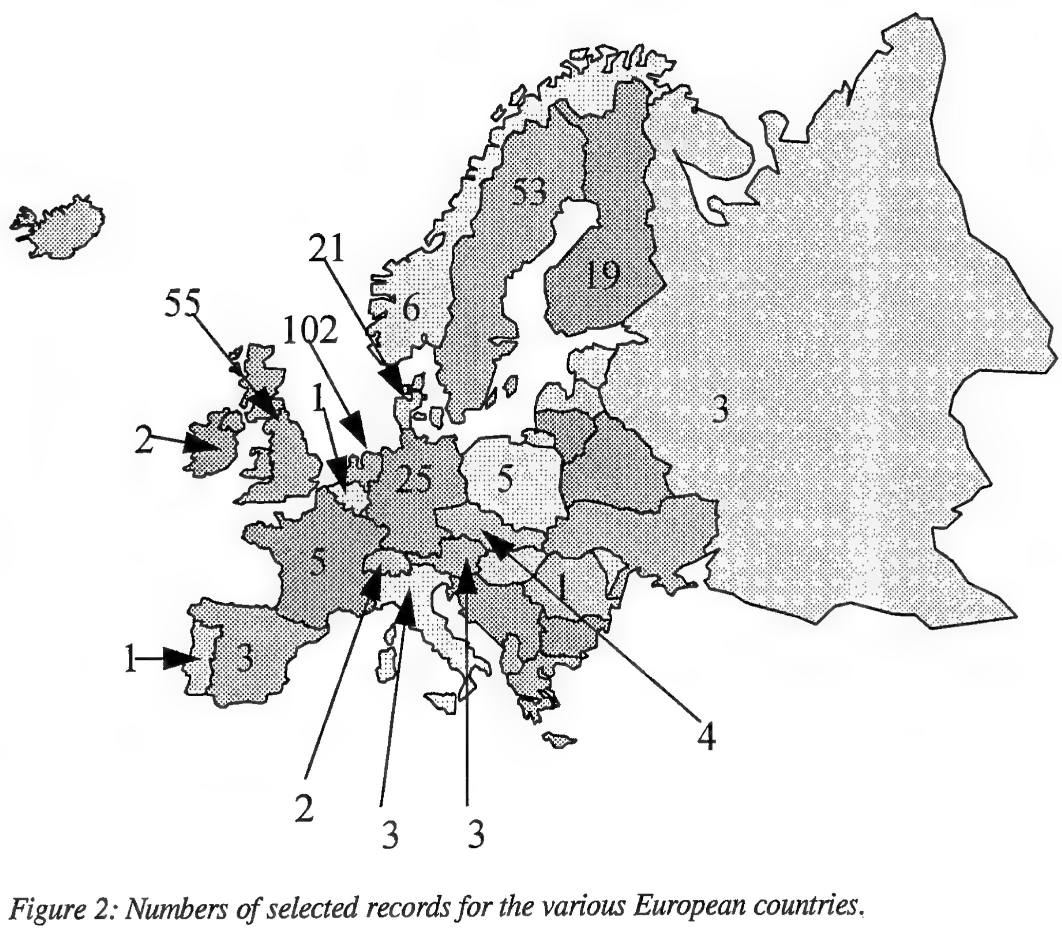

Figure 2: Numbers of selected records for the various European countries.

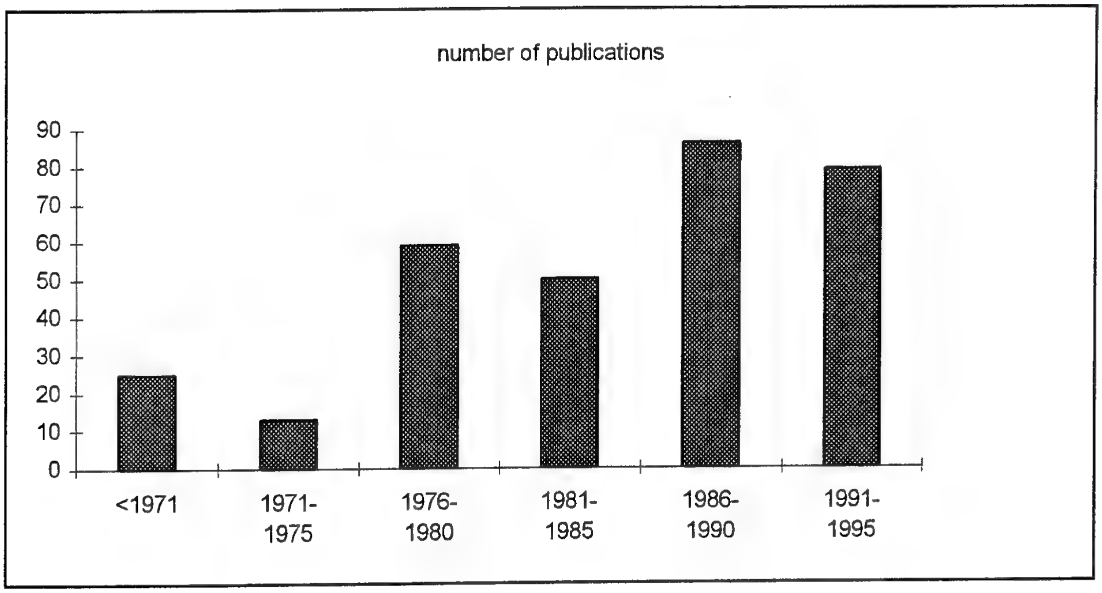

Figure 3: *Frequency distribution of publication years of selected records.*

Figure 3 gives the distribution of selected records over the years of publication. Most of the references are from the last decade. This is mainly due to the facts that the TNOLIT literature system is started in 1988, that older literature is very descriptive, and that the inquiries for additional references were restricted to publications from 1990 onwards. It was originally planned to acquire older references on basis of cited literature in the selected publications. This has only been done for some publications present in the TNOLIT system at the start of the project. Late receipt of requested publications from other institutes made it impossible to proceed with this strategy. A check on the cited literature in 10 references published in 1994 and 1995 learns that from the 363 cited references, 111 references seem to meet the selection criteria for this compilation. Only 18 of these suitable citations, are included in the present selection, another 16 were applied for, but not received.

This implies that the compilation of European literature is not complete. It is estimated that another 500 suitable European publications can be retrieved by further tracing citations or by contacting main researchers. However, the selected literature seems to be a comprehensive representation of the kind of studies on wetland processes throughout Europe, probably with the exception of the Eastern European countries. It is expected from the titles and authors,

that most of the cited references not present in the selection are similar type of studies but from an older date.

1.6 Outline of the report

For a synoptic review of selected references, the various aspects of wetland functioning are categorized in four topics, conform the structure and wording applied by Mitsch & Gosselink (1988). Each topic is dealt with in one of the next chapters:

Chapter 2 - *Wetland soils*
Chapter 3 - *Geochemistry of wetland soils*
Chapter 4 - *Biology of wetlands*
Chapter 5 - *Wetland ecosystem development*

Each chapter starts with a general introduction to the relevant basic wetland processes. Allied processes are elaborated in a few paragraphs, each consisting of a table with the number of relevant references for each single process mentioned in the "Matrix of Information", a listing of the relevant references and a synoptic text characterizing these references and summarizing the main facts and figures.

Table 1 gives the number of records per class of allied processes, as described in single paragraphs in the next chapters. The best covered issues are element cycling through vegetation and tolerances of plants to wetland soil conditions. This reflects the traditional importance of plant ecology in European wetland studies. Soil studies mainly refer to transformations of N and P, which are the most important nutrients for wetland vegetation. Other issues being adressed more extensively are studies on soil redox processes, sediment-water exchanges (viz. as part of eutrophication studies) and production/decomposition of organic matter (C-transformations), mainly under the influence of US literature. But even these studies are in most cases directly coupled to plant ecology.

Table 1: Number of records per class of allied processes (see indicated paragraphs).

Soils		
redox potential/soil oxygen	§2.2	45 records
soil characteristics	§2.3	24 records
Geochemistry		
N-transformations	§3.2	90 records
S-transformations	§3.3	17 records
C-transformations	§3.4	69 records
P-transformations	§3.5	62 records
Fe/Mn-transformations	§3.6	13 records
Toxicants-tranformations	§3.7	6 records
Sediment-water exchange	§3.8	56 records
Biology		
Microbial	§4.2	29 records
Element cycles vegetation	§4.3	104 records
Element cycles algae	§4.4	12 records
Effect vegetation on soils	§4.5	38 records
Effect algae on soils	§4.6	7 records
Effect fauna on soils	§4.7	13 records
Tolerances of wetland conditions	§4.8	92 records
Ecosystem		
Succession and zonation	§5.2	42 records
Climatic disturbances	§5.3	16 records
Habitat management	§5.4	4 records

1.7 References

Gopal B., J. Kvet, J. Löffler, V. Masing & B.C. Patten (1990): Definition and classification.
In: B.C. Patten, S.E. Jorgensen & H. Dumont (eds.), Wetlands and shallow continental waterbodies. Vol. 1. Natural and human relationships. SPB Academic Publishing, The Haque. pp. 9-15.

Gore A.J.P. ed. (1983): Mires: Swamp, bog, fen and moor. General studies.
Ecosystems of the world. Vol. 4a. Elsevier, Amsterdam.

Mitsch W.J. & J.G. Gosselink (1993): Wetlands.
Van Nostrand Reinold, New York. 2nd ed.

UCN (1971): International Convention on Wetlands of International Importance especially as Waterfowl Habitat.2 February 1971, Ramsar, Iran.

2. WETLAND SOILS

2.1 General introduction

An elementary factor in the development of wetland soils is the hydrology, viz. the frequency and cause of immersion or submersion. The wetness of soils can be determined by external factors (flooding or groundwater flows) or internal factors (failure to dry out). The frequency and duration of soil immersion is refered to as hydroperiod. The amplitude of water depth relative to soil surface level is another important feature of wetland soils.

Due to microbial processes and decreased oxygen diffusion, a wet soil tends to become anoxic or reduced. Soil texture and organic content determine the actual redox potential. At both extremes, mineral (hydric) soils and organic (peaty) soils, viz. bogs, can be distinguished respectively, but the soil is generally a mixture of a mineral and an organic fraction.

Wetland soil development is either endogenously governed by partial decomposition of wetland plant material or exogenously governed by sedimentation of suspended particles. Consolidation and compaction are physical processes in wetland soil development.

Measurements of physical soil characteristics can be used for delineation of wetlands.

2.2 Redox potential and soil oxygen

Table 2: The processes extracted from the "Matrix of Information on Wetland Processes" referred to in this section. For each process/category combination the number of relevant european literature records is indicated. The total can be smaller than the sum, due to references addressing more processes/categories.

Process	Description	Lab	Field	Computer
Redox Potential	7	7	4	2
Soil Oxygen	8	11	14	2
Total	14	16	17	3

In total 45 literature records regarding "redox potential and soil oxygen" have been selected and reviewed. There is a remarkable distinction between studies of oxygen dynamics of wetland soils and studies of redox potential of wetland soils. Only in a few publications both aspects are concerned.

Most records catagorized under "description" and "computer" are reviews or (mathematical) descriptive studies in which the redox potential or oxygen level is included in the description of soil processes (viz. S, P, N transformations), sediment-water exchanges and vegetation dynamics. Only a few publications concentrate on the measurement of soil oxygen dynamics itself. In most cases, soil oxygen dynamics is measured from the oxygen consumption of soils (e.g. record 16), of sediment cores (e.g. record 30), and in flux chambers (e.g. record 136). The soil oxygen content is determined using bore-holes (record 11), silver rods (record 256) or microelectrodes (e.g. record 212). The oxygen concentration in water is also determined by the Winkler titration (e.g. record 316). Fluxes of oxygen on the sediment-water interface are estimated from measurements of the oxygen profile in the sediment top layer and oxygen concentrations in the overlying water (e.g. records 247, 249).

Redox measurements are mainly performed by plant ecologists using platinum microelectrodes in the rhizophere of various marsh plant species (e.g. record 234). In a few studies, the redox potential is related to iron and manganese transformations (e.g. 227).

Redox potential:

Description:	50, Lijklema L., In: H.L. Golterman (ed.), Interactions between sediments and freshwater. pp. 313-317., (1977)
	80, Verhoeven J.T.A., The Utrecht Plant Ecology News Report 11:5-21. (in Dutch, English summary), (1990)
	109, Weisner S.E.B., Ambio 23:363-366., (1994)
	113, Schot P.P., Ph.D. Thesis University of Utrecht., (1991)
	189, Brinkman R., In: B.C. Patten & S.E. Jorgensen (eds.), Wetlands and shallow water bodies. pp. 37-59., (1990)
	201, Armstrong W., In: J.R. Etherington (ed.), Environmental plant ecology. 2nd ed. pp. 290-330., (1982)
	297, Boström B., Arch. Hydrobiol. Beih. Ergebn. Limnol. 18:5-59., (1982)
Lab:	26, Pearson J., J. Exp. Bot. 39:363-374., (1988)
	49, Groot C.J. de, Verh. Int. Ver. Limnol. 24:3029-3035., (1991)
	118, Jones H.E., J. Ecol. 58:487-496., (1970)
	226, P.E.J. Laan, Ph.D. Thesis, University of Nijmegen., (1990)
	227, Diggelen J. van, Ph.D. Thesis, Free University Amsterdam., (1988)
	229, Otte M.R., Ph.D. Thesis, Free University Amsterdam., (1991)
	240, Iremonger S.F., New Phytol. 109:491-497., (1988)
Field:	227, Diggelen J. van, Ph.D. Thesis, Free University Amsterdam., (1988)
	229, Otte M.R., Ph.D. Thesis, Free University Amsterdam., (1991)
	234, Armstrong W., J. Ecol. 73:323-339., (1985)
	307, Gerlach A., Oecol. Plant. 13:163-174. (in German, English abstract), (1978)
Computer:	23, Kemmers R.H., ICW Rapporten (nieuwe serie) 14. 20 pp. (in Dutch), (1985)
	91, Eck G.Th.M. van, In: P.G. Sly (ed.), Sediments and water interactions. Springer-Verlag, New York. pp. 189-301., (1986)

Soil oxygen:

Description:	14, Loach K., J. Ecol. 56:117-127., (1968)
	52, Sly P.G. (ed.), Proceedings of the Third International Symposium on Interactions Between Sediments and Water, (1986)
	84, Winter M., The Utrecht Plant Ecology News Report 4:123-140., (1985)
	117, Oorschot M.M.P. van, The Utrecht Plant Ecology News Report 11:64-85. (in Dutch, English abstract), (1990)
	120, Best E.P.H., Developments in Hydrobiology 88. Kluwer Academic Publishers, Dordrecht. - Hydrobiologia 265., (1993)
	200, Drew M.C., Plant Soil 75:179-199., (1983)

	201, Armstrong W., In: J.R. Etherington (ed.), Environmental plant ecology. 2nd ed. pp. 290-330., (1982)
	224, Adam P., Cambridge Studies in Ecology. Cambridge University Press, Cambridge. 461 pp., (1990)
Lab:	11, Haycock N.E., Hydrol. Process. 7:287-295., (1993)
	30, Andersen F.O., Holarctic Ecol. 4:66-72., (1981)
	51, Persson A., Opera Botanica 6(3). 100 pp., (1962)
	53, Sonesson M. (ed.), Swedish Natural Science Research Council, Ecological Bulletins 30. 313 pp., (1980)
	136, Hall P.O.J., Limnol. Oceanogr. 34:734-746., (1989)
	212, Bakker J.F., Ph.D. Thesis, University of Groningen., (1992)
	218, Granéli W., In: H.L. Golterman (ed.), Interactions between sediments and freshwater. pp. 276., (1977)
	234, Armstrong W., J. Ecol. 73:323-339., (1985)
	241, Andersen J.M., In: H.L. Golterman (ed.), Interactions between sediments and freshwater. pp. 357-362., (1977)
	247, Kamp-Nielsen L., In: H.L. Golterman (ed.), Interactions between sediments and freshwater. pp. 277-285., (1977)
	249, Stevens R.J., In: H.L. Golterman (ed.), Interactions between sediments and freshwater. pp. 343-347., (1977)
	250, Jorgensen B.B., Limnol. Oceanogr. 22:814-832., (1977)
	256, Reinikainen A., Ann. Bot. Fennici 21:79-101., (1984)
	289, Scholten M.C.Th., TNO report R94/049., (1994)
Field:	23, Kemmers R.H., ICW Rapporten (nieuwe serie) 14. 20 pp. (in Dutch), (1985)
	136, Hall P.O.J., Limnol. Oceanogr. 34:734-746., (1989)
Computer:	36, Marquenie J.M., TNO report V14, Den Helder., (1985)
	95, Marquenie J.M., TNO report R85/075., (1985)
	118, Jones H.E., J. Ecol. 58:487-496., (1970)
	137, Henriksen K., Mar. Biol. 61:299-304., (1981)
	212, Bakker J.F., Ph.D. Thesis, University of Groningen., (1992)
	217, Banoub M.W., In: H.L. Golterman (ed.), Interactions between sediments and freshwater. pp. 324-330., (1977)
	226, P.E.J. Laan, Ph.D. Thesis, University of Nijmegen., (1990)
	232, King D., FEMS Microbiol. Ecol. 31:23-28., (1985)
	289, Scholten M.C.Th., TNO report R94/049., (1994)
	294, Rysgaard S., Limnol. Oceanogr. 39:1643-1652., (1994)
	316, Pelegri S.P., Mar. Biol. 121:253-258., (1994)

2.3 Soil characteristics

Table 3: The processes extracted from the "Matrix of Information on Wetland Processes" referred to in this section. For each process/category combination the number of relevant european literature records is indicated. The total can be smaller than the sum, due to references addressing more processes/categories.

Process	Description	Lab	Field	Computer
Sedimentation	5	1	4	2
Permeability	5	0	6	2
Consolidation	2	0	0	0
Compaction	1	0	1	0
Total	11	1	10	4

In total 24 literature records regarding "soil characteristics" have been selected and reviewed. Most of these references are dealing with either descriptive studies or field studies regarding sedimentation and permeability. Remarkably few computer studies have been found.

All studies related to sedimentation are part of budget studies concerning the question as to what extent wetland soils act as a sink for settled elements (viz. N and P), except for two papers that are dealing with the measurement of marsh accretion on the basis of radio-isotope measurements (record 179) and the measurement of sedimentation using sediment-traps (record 247).

The studies related to permeability are mainly concerning ground water flows as the main vectors for nutrient dynamics and carbon-transformations in wetland soils. A few papers (records 47, 265) are dealing with the subsequent groundwater quality (salinization and alkalinization) and associated vegetation characteristics (plant species as indicators of ground water quality and quantity). Only one paper (record 63) is concerning a method for water

budget measurements, while another paper (record 208) is describing long-term transport of groundwater in deep peat on the basis of 14C and tritium age-determinations. Soil compaction, as part of soil ripening, is measured as an increase in soil density (record 184).

Sedimentation:

Description:	52, Sly P.G. (ed.), Proceedings of the Third International Symposium on Interactions Between Sediments and Water, (1986)
	79, Lijklema L., The Utrecht Plant Ecology News Report 11:44-51., (1990)
	102, Hemminga M.A., Mar. Ecol. Prog. Ser. 71:85-96., (1991)
	197, Olsson H., Vatten 47:263-272. (in Swedish, English abstract)., (1991)
	224, Adam P., Cambridge Studies in Ecology. Cambridge University Press, Cambridge. 461 pp., (1990)
Lab:	288, Scholten M.C.Th., TNO report R94/073., (1994)
Field:	39, Dykyjova D., Ecological Studies 28. Springer-Verlag, Berlin. 464 pp., (1978)
	92, Damiani V., In: P.G. Sly (ed.), Sediments and water interactions. Springer-Verlag, New York. pp. 13-25., (1986)
	179, Oenema O., Est. Coast. Shelf Sci. 26:379-394., (1988)
	247, Kamp-Nielsen L., In: H.L. Golterman (ed.), Interactions between sediments and freshwater. pp. 277-285., (1977)
Computer:	208, Charman D.J., Suo 43:199-201., (1992)
	247, Kamp-Nielsen L., In: H.L. Golterman (ed.), Interactions between sediments and freshwater. pp. 277-285., (1977)

Permeability:

Vertical:

Description:	78, Koerselman W., The Utrecht Plant Ecology News Report 11:22-43. (in Dutch, English summary), (1990)
	80, Verhoeven J.T.A., The Utrecht Plant Ecology News Report 11:5-21. (in Dutch, English summary), (1990)
	82, Verhoeven J.T.A., Oecologia 72:557-561., (1987)
	113, Schot P.P., Ph.D. Thesis University of Utrecht., (1991)
Field:	39, Dykyjova D., Ecological Studies 28. Springer-Verlag, Berlin. 464 pp., (1978)
	60, Koerselman W., Ph.D. Thesis University of Utrecht. 164 pp., (1989)
	62, Koerselman W., J. Ecol. 78:428-442., (1990)
	63, Koerselman W., Wetl. Ecol. Manage. 1:31-43., (1989)
	112, Wassen M.J., Ph.D. Thesis University of Utrecht., (1990)
	265, Bakker J.P., Acta Bot. Neerl. 36:39-58., (1987)
Computer:	60, Koerselman W., Ph.D. Thesis University of Utrecht. 164 pp., (1989)
	311, Jorgensen S.E., In: W.J. Mitsch et al. (eds.), Wetland modelling. pp. 133-151., (1988)

Permeability:
Lateral:

Description:	47, Bernaldez F.G., Geoderma 55:273-288., (1992)
	113, Schot P.P., Ph.D. Thesis University of Utrecht., (1991)
Field:	60, Koerselman W., Ph.D. Thesis University of Utrecht. 164 pp., (1989)
	62, Koerselman W., J. Ecol. 78:428-442., (1990)
	63, Koerselman W., Wetl. Ecol. Manage. 1:31-43., (1989)
	112, Wassen M.J., Ph.D. Thesis University of Utrecht., (1990)
	265, Bakker J.P., Acta Bot. Neerl. 36:39-58., (1987)
Computer:	60, Koerselman W., Ph.D. Thesis University of Utrecht. 164 pp., (1989)
	311, Jorgensen S.E., In: W.J. Mitsch et al. (eds.), Wetland modelling. pp. 133-151., (1988)

Consolidation:

Description:	79, Lijklema L., The Utrecht Plant Ecology News Report 11:44-51., (1990)
	189, Brinkman R., In: B.C. Patten & S.E. Jorgensen (eds.), Wetlands and shallow water bodies. pp. 37-59., (1990)

Compaction:

Description:	189, Brinkman R., In: B.C. Patten & S.E. Jorgensen (eds.), Wetlands and shallow water bodies. pp. 37-59., (1990)
Field:	184, Malmer N., Oikos 43:171-182., (1984)

3. GEOCHEMISTRY OF WETLAND SOILS

3.1 General introduction

The wet, reduced conditions have a strong impact on the transformation of chemical elements present in the wetland soil. CH_4 (methane) and S^{2-} (sulphide) are produced in strictly anaerobic soils. In facultatively aerobic soils, these elements are available as CO_2 and SO_4^{2-}. Iron and manganese shift from Fe^{3+} and Mn^{4+} under fully oxidized conditions towards Fe^{2+} and Mn^{2+} under reduced conditions. Depending upon soil conditions, nitrogen is available in organic form, as ammonium (NH_4^+), volatile N_2 or nitrate/nitrite (NO_3^-/NO_2^-). Phosphate and metals also show such transformations induced by soil conditions. Organic chemicals (including xenobiotic toxicants) are subject to degradation processes, although at a much slower rate in wet and reduced soils.

An important question is whether a wetland soil acts as a sink or a source for chemicals (elements). Generally it is a sink for organic compounds, but a source for their inorganic elements, and can, thus, be characterized at best as a transformer. Biomobility of toxicants in wetland soils is also dependent upon soil conditions.

Measurements of geochemical characteristics of wetland soils can be used for the assessment of potential wetland functioning.

3.2 N-transformations

Table 4: The processes extracted from the "Matrix of Information on Wetland Processes" referred to in this section. For each process/category combination the number of relevant european literature records is indicated. The total can be smaller than the sum, due to references addressing more processes/categories.

Process	Description	Lab	Field	Computer
N Transformation	27	X	X	X
Denitrification	11	13	17	6
Nitrification	6	11	14	5
NH3 Volatilization	1	0	1	1
Ammonification (NH_{4+})	3	9	9	3
Total	41	19	27	7

In total 90 literature records regarding "N-transformations" have been selected and reviewed. Most of these records are dealing with (de)nitrification.

Most of the descriptive studies are related to the N-cycling in connection to eutrophication of surface waters. It is remarkable that a few studies focus on the loss of mineralized N from wetland soils, contributing to eutrophication problems in surface waters, while most of the others focus on the loss of N from surface waters, through accumulation of N in wetland soils and vegetation and denitrification. In general, it can be concluded that wetlands are able to reduce the nutrient content of surface waters.
A few studies concern the subsequent detrimental consequences of internal N-enrichment of oligotrophic peat-bog vegetation. No detrimental effects were recorded for marshy (viz. reedswamps) and woody vegetations.
The development of reed swamps as a kind of helophyte filters cleaning surface waters is a very popular issue in European wetland management.

There are various methods used to characterize and measure the microbial nitrogen transformations, reviewed in records 25 and 59. Most of these methods are *in situ* or *in vitro* incubations of soil cores (e.g. records 5 and 8), with only a few radio-isotope (^{15}N) studies (i.e. record 87), *in situ* gaschromotography (record 195) or bell-jar studies (record 237).

In the incubaton studies, denitrification is determined from a decrease in concentration of NO_3 (e.g. records 5, 9, 30, 83, 162, 241, 315, 316), N_2 production (record 104) or N_2O production by using the acetylene blocking system (records 109, 110, 232, 258, 284) after enrichement of soil samples with nitrate. In some cases labelled ^{15}N is used (e.g. records 11, 29, 86). Nitrification and ammonification are determined from the fractionation of organic N, NH_4^+, NO_2^- and NO_3^- before and after incubation of soils (viz. records 23, 137, 307) or during a time series (record 29). The ratio $^{15}N/^{14}N$ is another basis for calculation of nitrification rates in denitrification studies with labelled NO_3 (records 294, 315).

In most wetland soils decomposition of organic material is the main source for inorganic nitrogen (viz. ammonium). In marshes, ammonification and subsequent nitrification of organic material is almost complete, resulting in an increased C/N ratio of the detritus. However, nitrogen is in most cases the limiting factor for plant growth during the growing season, resulting in nitrate depletion. viz. in marshes and riperian woods. This explains the relatively low denitrification rate in wetland soils, despite the high denitrification capacity when nitrate is available. At low pHs in acid peaty soils, the microbial N-transformation is strongly reduced. Liming, however, does not have a large influence in wetland soils.

Cyanobacteria represent a potential high capacity for N_2-fixation in wetlands, being the main N-source in tundra soils. In marshes and woodlands, N_2 fixation is usually reduced by shading from the emergent vegetation. In peat-bogs, cyanobacteria live in strong harmonization with the bogmosses. External N-supply from surface waters results in a less strong N-limitation in lower (salt)marsh zones. N_2 fixation is generally measured from acetylene reduction (some methods in records 246, 258, 274).

N Transformations:

Description:

1, Verhoeven J.T.A., J. Ecol. 78:713-726., (1990)

39, Dykyjova D., Ecological Studies 28. Springer-Verlag, Berlin. 464 pp., (1978)

40, Kuntze H., Telma 18:61-72. (in German, English abstract), (1988)

43, Lundin L., Vatten 47:301-304., (1991)

51, Persson A., Opera Botanica 6(3). 100 pp., (1962)

52, Sly P.G. (ed.), Proceedings of the Third International Symposium on Interactions Between Sediments and Water, (1986)

68, Malmer N., In: M. Sonesson (ed.), Ecology of a subarctic mire. Ecological Bulletins (Stockholm) 30:63-95., (1980)

71, Cristofor S., Hydrobiologia 251:143-148., (1993)

72, Pieczynska E., Hydrobiologia 251:49-58., (1993)

78, Koerselman W., The Utrecht Plant Ecology News Report 11:22-43. (in Dutch, English summary), (1990)

79, Lijklema L., The Utrecht Plant Ecology News Report 11:44-51., (1990)

84, Winter M., The Utrecht Plant Ecology News Report 4:123-140., (1985)

97, Koerselman W., Landschap 10(4):31-44. (in Dutch), (1993)

108, Jacks G., Ambio 23:358-362., (1994)

114, Kemmers R.H., The Utrecht Plant Ecology News Report 10:7-22. (in Dutch, English Abstract), (1990)

117, Oorschot M.M.P. van, The Utrecht Plant Ecology News Report 11:64-85. (in Dutch, English abstract), (1990)

119, Koerselman W., In: J.T.A. Verhoeven (ed.), Fens and bogs in the Netherlands: pp. 397-432., (1992)

120, Best E.P.H., Developments in Hydrobiology 88. Kluwer Academic Publishers, Dordrecht. - Hydrobiologia 265., (1993)

184, Malmer N., Oikos 43:171-182., (1984)

185, Armentano T.V., In: B.C. Patten & S.E. Jorgensen (eds.), Wetlands and shallow water bodies. pp. 281-311., (1990)

191, Fleischer S., Ambio 20:271-272., (1991)

197, Olsson H., Vatten 47:263-272. (in Swedish, English abstract)., (1991)

201, Armstrong W., In: J.R. Etherington (ed.), Environmental plant ecology. 2nd ed. pp. 290-330., (1982)

242, Arts G.H.P., Freshwater Biol. 24:287-294., (1990)

280, Sarvala J., Hydrobiologia 86:41-53., (1982)

306, Denny P., Arch. Hydrobiol. Beih. Ergebn. Limnol. 27:1-25., (1987)

310, Logofet D.O., In: W.J. Mitsch et al. (eds.), Wetland modelling. pp. 55-66., (1988)

Denitrification:

Description:

8, Verhoeven J.T.A., Biogeochemistry 6:31-43., (1988)

25, Leonardson L., Vatten 48:221-230. (in Swedish, English abstract), (1992)

38, Ostendorp W., Telma 18:351-372. (in German, English abstract), (1988)

80, Verhoeven J.T.A., The Utrecht Plant Ecology News Report 11:5-21. (in Dutch, English summary), (1990)

100, Golterman H.L., Avan. Oceanol. Med. Bull. Inst. Oceanogr. Mon. Spec. 11:75-87., (1992)

102, Hemminga M.A., Mar. Ecol. Prog. Ser. 71:85-96., (1991)

	105, Jansson M., Ambio 23:320-325., (1994)
	106, Vought L.B.M., Ambio 23:342-348., (1994)
	110, Ahlgren I., Ambio 23:367-377., (1994)
	270, Duel H., The Utrecht Plant Ecology News Report 11:188-202. (in Dutch, English summary), (1990)
	281, Granhall U., Physiol. Plant. 36:88-94., (1976)
Lab:	5, El-Habr H., Hydrobiologia 192:223-232., (1990)
	60, Koerselman W., Ph.D. Thesis University of Utrecht. 164 pp., (1989)
	65, Rosswall T., In: M. Sonesson (ed.), Ecology of a subarctic mire. Ecological Bulletins (Stockholm) 30:209-234., (1980)
	83, Golterman H.L., Verh. Int. Ver. Limnol. 24:3025-3028., (1991)
	104, Pelegri S.P., Mar. Ecol. Prog. Ser. 105:285-290., (1994)
	109, Weisner S.E.B., Ambio 23:363-366., (1994)
	162, Kaila A., J. Sci. Agric. Soc. Finland 25:37-46., (1953)
	212, Bakker J.F., Ph.D. Thesis, University of Groningen., (1992)
	232, King D., FEMS Microbiol. Ecol. 31:23-28., (1985)
	284, Ambus P., Soil Sci. Soc. Am. J. 55:994-997., (1991)
	294, Rysgaard S., Limnol. Oceanogr. 39:1643-1652., (1994)
	315, Sloth N.P., Mar. Ecol. Prog. Ser. 116:163-170., (1995)
	316, Pelegri S.P., Mar. Biol. 121:253-258., (1994)
Field:	5, El-Habr H., Hydrobiologia 192:223-232., (1990)
	9, Forès E., Mar. Ecol. Prog. Ser. 106:283-290., (1994)
	11, Haycock N.E., Hydrol. Process. 7:287-295., (1993)
	29, Verhoeven J.T.A., Oecologia 60:25-33., (1983)
	30, Andersen F.O., Holarctic Ecol. 4:66-72., (1981)
	32, Brock Th.C.M., Aquat. Bot. 17:189-214., (1983)
	41, Leonardson L., Vatten 47:315-316., (1991)
	42, Durka W., Nature 372:765-767., (1994)
	53, Sonesson M. (ed.), Swedish Natural Science Research Council, Ecological Bulletins 30. 313 pp., (1980)
	86, Haycock N.E., J. Environ. Qual. 22:273-278., (1993)
	107, Fleischer S., Ambio 23:349-357., (1994)
	174, Abd.Aziz S.A., In: R.I. Jefferies & A.J. Davy (eds.), Ecological processes in the coastal environments. pp. 385-398., (1979)
	195, Silvola J., Suo 43:263-266., (1992)
	231, Henriksen K., Neth. Inst. Sea Res. Publ. Ser. 10:51-69., (1984)
	237, Tirén T., In: H.L. Golterman (ed.), Interactions between sediments and freshwater.pp. 363-369., (1977)
	241, Andersen J.M., In: H.L. Golterman (ed.), Interactions between sediments and freshwater. pp. 357-362., (1977)
	258, Abd.Aziz S.A., Est. Coast. Shelf Sci. 22:689-704., (1986)
Computer:	9, Forès E., Mar. Ecol. Prog. Ser. 106:283-290., (1994)
	17, Pinay G., Regul. Rivers Res. Manage. 2:507-516., (1988)

	69, Dorge J., Ecol. Modell. 75/76:409-420., (1994)
	91, Eck G.Th.M. van, In: P.G. Sly (ed.), Sediments and water interactions. Springer-Verlag, New York. pp. 189-301., (1986)
	111, Arheimer B., Ambio 23:378-386., (1994)
	311, Jorgensen S.E., In: W.J. Mitsch et al. (eds.), Wetland modelling. pp. 133-151., (1988)

Nitrification:

Description:	31, Basilier K., Oikos 34:239-242., (1980)
	80, Verhoeven J.T.A., The Utrecht Plant Ecology News Report 11:5-21. (in Dutch, English summary), (1990)
	100, Golterman H.L., Avan. Oceanol. Med. Bull. Inst. Oceanogr. Mon. Spec. 11:75-87., (1992)
	110, Ahlgren I., Ambio 23:367-377., (1994)
	183, Verhoeven J.T.A., Aquat. Bot. 25:117-137., (1986)
	263, Lee J.A., In: J.T.A. Verhoeven et al. (eds.), Vegetation structure in relation to carbon and nutrient economy. pp. 137-147., (1988)
Lab:	59, Gerlach A., Scripta Geobotanica 5. 115 pp. (in German, English abstract), (1973)
	60, Koerselman W., Ph.D. Thesis University of Utrecht. 164 pp., (1989)
	65, Rosswall T., In: M. Sonesson (ed.), Ecology of a subarctic mire. Ecological Bulletins (Stockholm) 30:209-234., (1980)
	137, Henriksen K., Mar. Biol. 61:299-304., (1981)
	150, Kaila A., J. Sci. Agric. Soc. Finland 26:79-95., (1954)
	212, Bakker J.F., Ph.D. Thesis, University of Groningen., (1992)
	232, King D., FEMS Microbiol. Ecol. 31:23-28., (1985)
	294, Rysgaard S., Limnol. Oceanogr. 39:1643-1652., (1994)
	298, Verhoeven J.T.A., The Utrecht Plant Ecology News Report 2:64-70. (in Dutch, English abstract), (1985)
	315, Sloth N.P., Mar. Ecol. Prog. Ser. 116:163-170., (1995)
	316, Pelegri S.P., Mar. Biol. 121:253-258., (1994)
Field:	9, Forès E., Mar. Ecol. Prog. Ser. 106:283-290., (1994)
	23, Kemmers R.H., ICW Rapporten (nieuwe serie) 14. 20 pp. (in Dutch), (1985)
	42, Durka W., Nature 372:765-767., (1994)
	53, Sonesson M. (ed.), Swedish Natural Science Research Council, Ecological Bulletins 30. 313 pp., (1980)
	59, Gerlach A., Scripta Geobotanica 5. 115 pp. (in German, English abstract), (1973)
	173, Stewart G.R., New Phytol. 72:539-546., (1973)
	174, Abd.Aziz S.A., In: R.I. Jefferies & A.J. Davy (eds.), Ecological processes in the coastal environments. pp. 385-398., (1979)
	175, Henriksen K., In: R.I. Jefferies & A.J. Davy (eds.), Ecological processes in the coastal environments. pp. 373-384., (1977)
	231, Henriksen K., Neth. Inst. Sea Res. Publ. Ser. 10:51-69., (1984)
	246, Waughman G.J., In: Proceedings of the 4th international peat congress, Finland, 1972. Vol. 1. pp. 309-318., (1972)
	258, Abd.Aziz S.A., Est. Coast. Shelf Sci. 22:689-704., (1986)
	274, Granhall U., In: F.E. Wielgolaski (ed.), Fennoscandian Tundra Ecosystems. Part 1.pp. 305-315., (1975)
	285, Grootjans A.P., Acta Oecol. Oecol. Plant. 6:403-417., (1985)

	307, Gerlach A., Oecol. Plant. 13:163-174. (in German, English abstract), (1978)
Computer:	9, Forès E., Mar. Ecol. Prog. Ser. 106:283-290., (1994)
	23, Kemmers R.H., ICW Rapporten (nieuwe serie) 14. 20 pp. (in Dutch), (1985)
	69, Dorge J., Ecol. Modell. 75/76:409-420., (1994)
	91, Eck G.Th.M. van, In: P.G. Sly (ed.), Sediments and water interactions. Springer-Verlag, New York. pp. 189-301., (1986)
	311, Jorgensen S.E., In: W.J. Mitsch et al. (eds.), Wetland modelling. pp. 133-151., (1988)

NH3 volatilization:

Description:	100, Golterman H.L., Avan. Oceanol. Med. Bull. Inst. Oceanogr. Mon. Spec. 11:75-87., (1992)
Field:	53, Sonesson M. (ed.), Swedish Natural Science Research Council, Ecological Bulletins 30. 313 pp., (1980)
Computer:	311, Jorgensen S.E., In: W.J. Mitsch et al. (eds.), Wetland modelling. pp. 133-151., (1988)

Ammonification:

Description:	38, Ostendorp W., Telma 18:351-372. (in German, English abstract), (1988)
	100, Golterman H.L., Avan. Oceanol. Med. Bull. Inst. Oceanogr. Mon. Spec. 11:75-87., (1992)
	110, Ahlgren I., Ambio 23:367-377., (1994)
Lab:	59, Gerlach A., Scripta Geobotanica 5. 115 pp. (in German, English abstract), (1973)
	65, Rosswall T., In: M. Sonesson (ed.), Ecology of a subarctic mire. Ecological Bulletins (Stockholm) 30:209-234., (1980)
	87, Blackburn T.H., In: A.W. Bourquin & P.H. Pritchard (eds.), Microbial degradation of pollutants in marine environments. pp. 148-190., (1979)
	101, Kristensen E., J. Exp. Mar. Biol. Ecol. 75:171-190., (1984)
	104, Pelegri S.P., Mar. Ecol. Prog. Ser. 105:285-290., (1994)
	162, Kaila A., J. Sci. Agric. Soc. Finland 25:37-46., (1953)
	212, Bakker J.F., Ph.D. Thesis, University of Groningen., (1992)
	315, Sloth N.P., Mar. Ecol. Prog. Ser. 116:163-170., (1995)
	316, Pelegri S.P., Mar. Biol. 121:253-258., (1994)
Field:	9, Forès E., Mar. Ecol. Prog. Ser. 106:283-290., (1994)
	23, Kemmers R.H., ICW Rapporten (nieuwe serie) 14. 20 pp. (in Dutch), (1985)
	29, Verhoeven J.T.A., Oecologia 60:25-33., (1983)
	53, Sonesson M. (ed.), Swedish Natural Science Research Council, Ecological Bulletins 30. 313 pp., (1980)
	57, Saebo S., Meld. Norges Landbrukshögsk. 49. 37 pp., (1970)
	59, Gerlach A., Scripta Geobotanica 5. 115 pp. (in German, English abstract), (1973)
	82, Verhoeven J.T.A., Oecologia 72:557-561., (1987)
	237, Tirén T., In: H.L. Golterman (ed.), Interactions between sediments and freshwater.pp. 363-369., (1977)
	285, Grootjans A.P., Acta Oecol. Oecol. Plant. 6:403-417., (1985)
Computer:	9, Forès E., Mar. Ecol. Prog. Ser. 106:283-290., (1994)
	23, Kemmers R.H., ICW Rapporten (nieuwe serie) 14. 20 pp. (in Dutch), (1985)
	69, Dorge J., Ecol. Modell. 75/76:409-420., (1994)

3.3 S-transformations

Table 5: The processes extracted from the "Matrix of Information on Wetland Processes" referred to in this section. For each process/category combination the number of relevant european literature records is indicated. The total can be smaller than the sum, due to references addressing more processes/categories.

Process	Description	Lab	Field	Computer
S Transformations	9	X	X	X
Sulfide/Sulfate	2	3	3	1
Hydrogen Sulfide	0	1	1	0
Total	11	3	3	1

In total 17 literature records regarding "S-transformations" have been selected and reviewed.

Most records concern the organic matter decomposition and subsequent sulphate reduction in wetland soils. Good methodical descriptions are available in records 248 (transformation of labelled sulphate into sulphide) and 250 (various methods to determine H_2S in sediment cores). In some records the interaction between the S-transformation and denitrification (record 83) or methane fluxes (record 302) are discussed. In none of the studies, the S-dipstick has been used.

S Transformations:

Description:	1, Verhoeven J.T.A., J. Ecol. 78:713-726., (1990) 38, Ostendorp W., Telma 18:351-372. (in German, English abstract), (1988) 87, Blackburn T.H., In: A.W. Bourquin & P.H. Pritchard (eds.), Microbial degradation of pollutants in marine environments. pp. 148-190., (1979) 115, Meuleman A.F.M., The Utrecht Plant Ecology News Report 10:23-38. (in Dutch), (1990) 116, Cals M.J.R., The Utrecht Plant Ecology News Report 10:39-46. (in Dutch), (1990) 120, Best E.P.H., Developments in Hydrobiology 88. Kluwer Academic Publishers, Dordrecht. - Hydrobiologia 265., (1993) 185, Armentano T.V., In: B.C. Patten & S.E. Jorgensen (eds.), Wetlands and shallow water bodies. pp. 281-311., (1990) 201, Armstrong W., In: J.R. Etherington (ed.), Environmental plant ecology. 2nd ed. pp. 290-330., (1982) 314, Kämäri J., Sci. Total Environ. 160/161:687-701., (1995)

Sulfide / sulfate:

Description:	26, Pearson J., J. Exp. Bot. 39:363-374., (1988) 84, Winter M., The Utrecht Plant Ecology News Report 4:123-140., (1985)
Lab:	83, Golterman H.L., Verh. Int. Ver. Limnol. 24:3025-3028., (1991) 227, Diggelen J. van, Ph.D. Thesis, Free University Amsterdam., (1988) 248, Abdollahi H., Microbial Ecol. 5:73-79., (1979)
Field:	248, Abdollahi H., Microbial Ecol. 5:73-79., (1979) 250, Jorgensen B.B., Limnol. Oceanogr. 22:814-832., (1977) 302, Freeman C., Soil. Biol. Biochem. 26:1439-1442., (1994)
Computer:	91, Eck G.Th.M. van, In: P.G. Sly (ed.), Sediments and water interactions. Springer-Verlag, New York. pp. 189-301., (1986)

Hydrogen sulfide:

Lab:	227, Diggelen J. van, Ph.D. Thesis, Free University Amsterdam., (1988)
Field:	250, Jorgensen B.B., Limnol. Oceanogr. 22:814-832., (1977)

3.4 C-transformations

Table 6: The processes extracted from the "Matrix of Information on Wetland Processes" referred to in this section. For each process/category combination the number of relevant european literature records is indicated. The total can be smaller than the sum, due to references addressing more processes/categories.

Process	Description	Lab	Field	Computer
Carbon Transformations	11	X	X	X
Methane Production	1	3	8	1
CO_2	1	3	9	1
Organic Material Accumulation	14	5	24	7
Total	24	11	32	7

In total 69 literature records regarding "C-transformations" have been selected and reviewed. Most studies are related to organic material accumulation, viz. detritus (including decomposition).

Carbon transformations are generally measured as part of the nutrient (N,P) cycles in wetlands (e.g. records 100, 306) and sulphate reduction due to microbial respiration (record 115). Methane production is measured in organic rich soils of peats (record 180), swamps (record 196) or tundras (record 296). The CH_4 and CO_2 fluxes from the sediments are seen as measures of mineralization rates, although plant roots can substantially contribute to CO_2 fluxes from soils (record 222).
Methane and CO_2 production by wetland soils are generally measured in enclosures ("closed chambers") above the soil (e.g. record 64), but sometimes directly in soil samples (e.g. record 208). Both compounds are measured using a GC, but in case of methane, Flame Ionization (GC-FI) is applied (e.g. record 196), while for CO_2, Infra Red analysis (GC-IR) is applied (e.g. record 222). A modified Warburg method for peat

soils is reported in record 220. In record 235, the CO_2 dynamics is derived from changes in C/organic matter ratio of soils.

In only a few studies real accumulation of organic matter in wetland soils has been determined. The most extensive study is reported in record 275, in which various techniques have been applied. In peat bogs, organic matter accumulation is similar to accretion as a result of *Sphagnum* growth and decomposition (record 45), or measured using dating methods (record 221). Detritus is, however, an important nutrient store in wetlands, besides vegetation (record 72). Decomposition of organic matter is usually measured from the loss of weight or loss of nutrients from litter incubated in meshbags (e.g. record 228). Decomposition of cellulose is measured by means of tensile strength loss of in-situ buried cotton strips (record 1). Fresh organic (plant) material is mainly decomposed by microbiota, supported by detritophagous fauna (record 308, 213, 235), while benthic fauna is responsible for the decomposition of older, refractionary material that may not easily be mineralized by bacteria.

C Transformations:

Description:

39, Dykyjova D., Ecological Studies 28. Springer-Verlag, Berlin. 464 pp., (1978)

99, Jansson M., Hydrobiologia 170:177-189., (1988)

100, Golterman H.L., Avan. Oceanol. Med. Bull. Inst. Oceanogr. Mon. Spec. 11:75-87., (1992)

109, Weisner S.E.B., Ambio 23:363-366., (1994)

115, Meuleman A.F.M., The Utrecht Plant Ecology News Report 10:23-38. (in Dutch), (1990)

185, Armentano T.V., In: B.C. Patten & S.E. Jorgensen (eds.), Wetlands and shallow water bodies. pp. 281-311., (1990)

190, Franzén L.G., Ambio 23:300-308., (1994)

224, Adam P., Cambridge Studies in Ecology. Cambridge University Press, Cambridge. 461 pp., (1990)

260, Kowalczewski A., Verh. Int. Ver. Limnol. 20:2182-2185., (1978)

306, Denny P., Arch. Hydrobiol. Beih. Ergebn. Limnol. 27:1-25., (1987)

308, Imhof G., Pol. Arch. Hydrobiol. 20:165-168., (1973)

Methane prod.:

Description:	180, Svensson B.H., Suo 43:183-190., (1992)
Lab:	196, Westermann P., Suo 43:289-292., (1992)
	209, Sundh I., Suo 43:267-269., (1992)
	253, Lien T., Suo 43:231-236., (1992)
Field:	38, Ostendorp W., Telma 18:351-372. (in German, English abstract), (1988)
	53, Sonesson M. (ed.), Swedish Natural Science Research Council, Ecological Bulletins 30. 313 pp., (1980)
	64, Svensson B.H., In: M. Sonesson (ed.), Ecology of a subarctic mire. Ecological Bulletins (Stockholm) 30:235-250., (1980)
	195, Silvola J., Suo 43:263-266., (1992)
	206, Martikainen P.J., Suo 43:237-240., (1992)
	253, Lien T., Suo 43:231-236., (1992)
	296, Svensson B.H., In: F.E. Wielgolaski (ed.), Fennoscandian Tundra Ecosystems. Part 1. pp. 279-286., (1975)
	302, Freeman C., Soil. Biol. Biochem. 26:1439-1442., (1994)
Computer:	91, Eck G.Th.M. van, In: P.G. Sly (ed.), Sediments and water interactions. Springer-Verlag, New York. pp. 189-301., (1986)

CO2 production:

Description:	87, Blackburn T.H., In: A.W. Bourquin & P.H. Pritchard (eds.), Microbial degradation of pollutants in marine environments. pp. 148-190., (1979)
Lab:	213, Ostergaard Andersen F., Limnol. Oceanogr. 37:1392-1403., (1992)
	222, Silvola J., Suo 43:259-262., (1992)
	316, Pelegri S.P., Mar. Biol. 121:253-258., (1994)
Field:	38, Ostendorp W., Telma 18:351-372. (in German, English abstract), (1988)
	53, Sonesson M. (ed.), Swedish Natural Science Research Council, Ecological Bulletins 30. 313 pp., (1980)
	64, Svensson B.H., In: M. Sonesson (ed.), Ecology of a subarctic mire. Ecological Bulletins (Stockholm) 30:235-250., (1980)
	195, Silvola J., Suo 43:263-266., (1992)
	220, Mannerkoski H., In: Proceedings of the 4th international peat congress, Finland, 1972. Vol. 1. pp. 319-326., (1972)
	222, Silvola J., Suo 43:259-262., (1992)
	228, Buth G.J.C., Ph.D. Thesis, University of Utrecht., (1993)
	235, Alkemade R., Mar. Ecol. Prog. Ser. 99:293-300., (1993)
	296, Svensson B.H., In: F.E. Wielgolaski (ed.), Fennoscandian Tundra Ecosystems. Part 1. pp. 279-286., (1975)
Computer:	91, Eck G.Th.M. van, In: P.G. Sly (ed.), Sediments and water interactions. Springer-Verlag, New York. pp. 189-301., (1986)

Organic mat. acc.:

Description:	19, Heal O.W., In: O.W. Heal & D.F. Perkins (eds.), Production ecology of British moors and montane grasslands. pp. 136-159., (1978)
	40, Kuntze H., Telma 18:61-72. (in German, English abstract), (1988)
	72, Pieczynska E., Hydrobiologia 251:49-58., (1993)
	79, Lijklema L., The Utrecht Plant Ecology News Report 11:44-51., (1990)
	80, Verhoeven J.T.A., The Utrecht Plant Ecology News Report 11:5-21. (in Dutch, English summary), (1990)
	86, Haycock N.E., J. Environ. Qual. 22:273-278., (1993)
	100, Golterman H.L., Avan. Oceanol. Med. Bull. Inst. Oceanogr. Mon. Spec. 11:75-87., (1992)
	117, Oorschot M.M.P. van, The Utrecht Plant Ecology News Report 11:64-85. (in Dutch, English abstract), (1990)
	120, Best E.P.H., Developments in Hydrobiology 88. Kluwer Academic Publishers, Dordrecht. - Hydrobiologia 265., (1993)
	186, Damman A.W.H., Suo 43:137-145., (1992)
	242, Arts G.H.P., Freshwater Biol. 24:287-294., (1990)
	264, Velimirov B., Arch. Hydrobiol. 121:1-20., (1991)
	306, Denny P., Arch. Hydrobiol. Beih. Ergebn. Limnol. 27:1-25., (1987)
	308, Imhof G., Pol. Arch. Hydrobiol. 20:165-168., (1973)
Lab:	4, Buth G.J.C., In: J.T.A. Verhoeven et al. (eds.), Vegetation structure in relation to carbon and nutrient economy. pp. 51-60., (1988)
	22, Sondergaard M., Oikos 36:331-347., (1981)
	169, Koncalova H., Wetl. Ecol. Manage. 2:199-211., (1993)
	275, Pieczynska E., Ekol. Pol. 32:387-440., (1984)
	289, Scholten M.C.Th., TNO report R94/049., (1994)
Field:	4, Buth G.J.C., In: J.T.A. Verhoeven et al. (eds.), Vegetation structure in relation to carbon and nutrient economy. pp. 51-60., (1988)
	30, Andersen F.O., Holarctic Ecol. 4:66-72., (1981)
	32, Brock Th.C.M., Aquat. Bot. 17:189-214., (1983)
	38, Ostendorp W., Telma 18:351-372. (in German, English abstract), (1988)
	45, Brock Th.C.M., Oecologia 80:44-52., (1989)
	48, Heckman C.W., Aquat. Bot. 25:139-151., (1986)
	53, Sonesson M. (ed.), Swedish Natural Science Research Council, Ecological Bulletins 30. 313 pp., (1980)
	74, Kühl H., Hydrobiologia 251:1-12., (1993)
	76, Gorham E., J. Ecol. 41:345-360., (1953)
	90, Balzer W., In: P.G. Sly (ed.), Sediments and water interactions. Springer-Verlag, New York. pp. 325-330., (1986)
	140, Jackson D., J. Ecol. 74:647-662., (1986)
	174, Abd.Aziz S.A., In: R.I. Jefferies & A.J. Davy (eds.), Ecological processes in the coastal environments. pp. 385-398., (1979)
	184, Malmer N., Oikos 43:171-182., (1984)
	194, Sakovets V., Suo 43:249-252., (1992)
	221, Tolonen K., Suo 43:277-280., (1992)

	228, Buth G.J.C., Ph.D. Thesis, University of Utrecht., (1993)
	256, Reinikainen A., Ann. Bot. Fennici 21:79-101., (1984)
	257, Reboredo F., Sci. Total Environ. 133:111-132., (1993)
	275, Pieczynska E., Ekol. Pol. 32:387-440., (1984)
	280, Sarvala J., Hydrobiologia 86:41-53., (1982)
	282, Clymo R.S., J. Ecol. 53:747-757., (1965)
	283, Menéndez M., Arch. Hydrobiol. 117:39-48., (1989)
	289, Scholten M.C.Th., TNO report R94/049., (1994)
	296, Svensson B.H., In: F.E. Wielgolaski (ed.), Fennoscandian Tundra Ecosystems. Part 1. pp. 279-286., (1975)
Computer:	9, Forès E., Mar. Ecol. Prog. Ser. 106:283-290., (1994)
	91, Eck G.Th.M. van, In: P.G. Sly (ed.), Sediments and water interactions. Springer-Verlag, New York. pp. 189-301., (1986)
	93, Svenssen B.H., In: M. Sonesson (ed.), Ecology of a subarctic mire. Ecological Bulletins (Stockholm) 30:283-301., (1980)
	181, Clymo R.S., Suo 43:127-136., (1992)
	207, Dierendonck M.C. van, Suo 43:203-206., (1992)
	309, Alexandrov G.A., In: W.J. Mitsch et al. (eds.), Wetland modelling. pp. 41-53., (1988)
	310, Logofet D.O., In: W.J. Mitsch et al. (eds.), Wetland modelling. pp. 55-66., (1988)

3.5 P-transformations

Table 7: The processes extracted from the "Matrix of Information on Wetland Processes" referred to in this section. For each process/category combination the number of relevant european literature records is indicated. The total can be smaller than the sum, due to references addressing more processes/categories.

Process	Description	Lab	Field	Computer
P Transformations	16	X	X	X
Soluble P	3	9	10	1
Exchangeable P	5	3	5	2
Total P	5	3	10	1
P Cycling	10	3	9	4
Total	30	9	20	5

In total 62 literature records regarding "P-transformations" have been selected and reviewed.

Phosphorus in wetland soils is mainly studied in order to estimate P-cycling in a wetland system, viz. the sink of P in wetland soils and the flux of soluble and bioavailable P from these soils. This is further explained from the sequence of transformations between various P-species in the wetland soils. Good reviews of P-cycling and P-transformations are records 306, respectively 119 and 210. Most records dealing with lab or field studies on P in wetland soils are addressing all the distinguished subprocesses. The various P-species or P-fractions are separated by means of a series of extractions. Records 6, 49 and 247 present various alternatives for such series. More simple extractions used to determine just total P are found in records 275 and 280.

The release of soluble P from sediments is regularly measured in the above standing water: in flasks (record 89), bell-jars (record 231), plastic bottles (record 82), or even flow-through

systems (record 101). Another way to calculate the P-flux is from a depth profile of total-P in sequent slices of sediment cores (record 247). The extraction of soluble-P is related to bioavailable-P for plants (record 251), while the depletion of bioavailable-P by growth of wetland vegetation is demonstrated with labelled P in record 292.

Specific aspects of P-cycling are addressed in a few papers. Records 350 and 247 describe the impact of Fe, pH, O_2, Eh and temperature on the P-cycling in wetland soils. Record 98 describes the P-flux through a wetland food chain. Record 79 describes the P-cycling in wetland marshes used for waste water treatment. Record 97 discusses the cause of wetland eutrophication in terms of external eutrophication (enriched surface waters) or internal eutrophication (enhanced transformation of the soil-P pool into soluble-P)

P Transformations:

Description:	7, Golterman H.L., Arch. Hydrobiol. Beih. Ergebn. Limnol. 30:1-4., (1988)
	40, Kuntze H., Telma 18:61-72. (in German, English abstract), (1988)
	52, Sly P.G. (ed.), Proceedings of the Third International Symposium on Interactions Between Sediments and Water, (1986)
	68, Malmer N., In: M. Sonesson (ed.), Ecology of a subarctic mire. Ecological Bulletins (Stockholm) 30:63-95., (1980)
	71, Cristofor S., Hydrobiologia 251:143-148., (1993)
	72, Pieczynska E., Hydrobiologia 251:49-58., (1993)
	78, Koerselman W., The Utrecht Plant Ecology News Report 11:22-43. (in Dutch, English summary), (1990)
	84, Winter M., The Utrecht Plant Ecology News Report 4:123-140., (1985)
	99, Jansson M., Hydrobiologia 170:177-189., (1988)
	114, Kemmers R.H., The Utrecht Plant Ecology News Report 10:7-22. (in Dutch, English Abstract), (1990)
	117, Oorschot M.M.P. van, The Utrecht Plant Ecology News Report 11:64-85. (in Dutch, English abstract), (1990)
	119, Koerselman W., In: J.T.A. Verhoeven (ed.), Fens and bogs in the Netherlands: pp. 397-432., (1992)
	120, Best E.P.H., Developments in Hydrobiology 88. Kluwer Academic Publishers, Dordrecht. - Hydrobiologia 265., (1993)
	183, Verhoeven J.T.A., Aquat. Bot. 25:117-137., (1986)
	210, Holtan H., Hydrobiologia 170:19-34., (1988)
	278, Leendertse P., Report Free University, Amsterdam. (in Dutch), (1992)

Soluble P:

Description:	27, Saebo S., Meld. Norges Landbrukshögsk. 48:1-10., (1969)
	100, Golterman H.L., Avan. Oceanol. Med. Bull. Inst. Oceanogr. Mon. Spec. 11:75-87., (1992)
	124, Dijk H.W.J. van, Acta Bot. Neerl. 34:301-319., (1985)
Lab:	6, Groot C.J. de, Hydrobiologia 192:143-148., (1990)
	33, Cuttle S.P., J. Soil Sci. 34:75-82., (1983)
	49, Groot C.J. de, Verh. Int. Ver. Limnol. 24:3029-3035., (1991)
	89, Jansson M., In: P.G. Sly (ed.), Sediments and water interactions. Springer-Verlag, New York. pp. 387-389., (1986)
	101, Kristensen E., J. Exp. Mar. Biol. Ecol. 75:171-190., (1984)
	216, Rippey B., In: H.L. Golterman (ed.), Interactions between sediments and freshwater. pp. 348-353., (1977)
	217, Banoub M.W., In: H.L. Golterman (ed.), Interactions between sediments and freshwater. pp. 324-330., (1977)
	251, Golterman H.L., In: H.L. Golterman (ed.), Interactions between sediments and freshwater. pp. 286-293., (1977)
	298, Verhoeven J.T.A., The Utrecht Plant Ecology News Report 2:64-70. (in Dutch, English abstract), (1985)
Field:	8, Verhoeven J.T.A., Biogeochemistry 6:31-43., (1988)
	29, Verhoeven J.T.A., Oecologia 60:25-33., (1983)
	53, Sonesson M. (ed.), Swedish Natural Science Research Council, Ecological Bulletins 30. 313 pp., (1980)
	58, Saebo S., Meld. Norges Landbrukshögsk. 47. 67 pp., (1968)
	70, Hillbricht-Ilkowska A., Hydrobiologia 251:257-268., (1993)
	147, Kaila A., J. Sci. Agric. Soc. Finland 28:142-167., (1956)
	170, Kaila A., J. Sci. Agric. Soc. Finland 28:90-104., (1956)
	247, Kamp-Nielsen L., In: H.L. Golterman (ed.), Interactions between sediments and freshwater. pp. 277-285., (1977)
	249, Stevens R.J., In: H.L. Golterman (ed.), Interactions between sediments and freshwater. pp. 343-347., (1977)
	256, Reinikainen A., Ann. Bot. Fennici 21:79-101., (1984)
Computer:	211, Jorgensen S.E., Ecol. Modell. 16:99-124., (1982)

Exchangeable P:

Description:	97, Koerselman W., Landschap 10(4):31-44. (in Dutch), (1993)
	100, Golterman H.L., Avan. Oceanol. Med. Bull. Inst. Oceanogr. Mon. Spec. 11:75-87., (1992)
	124, Dijk H.W.J. van, Acta Bot. Neerl. 34:301-319., (1985)
	245, Ahlgren I., In: H.L. Golterman (ed.), Interactions between sediments and freshwater. pp. 372-377., (1977)
	297, Boström B., Arch. Hydrobiol. Beih. Ergebn. Limnol. 18:5-59., (1982)
Lab:	6, Groot C.J. de, Hydrobiologia 192:143-148., (1990)
	49, Groot C.J. de, Verh. Int. Ver. Limnol. 24:3029-3035., (1991)
	251, Golterman H.L., In: H.L. Golterman (ed.), Interactions between sediments and freshwater. pp. 286-293., (1977)

Exchangeable P:

Field:	8, Verhoeven J.T.A., Biogeochemistry 6:31-43., (1988)
	53, Sonesson M. (ed.), Swedish Natural Science Research Council, Ecological Bulletins 30. 313 pp., (1980)
	170, Kaila A., J. Sci. Agric. Soc. Finland 28:90-104., (1956)
	247, Kamp-Nielsen L., In: H.L. Golterman (ed.), Interactions between sediments and freshwater. pp. 277-285., (1977)
	249, Stevens R.J., In: H.L. Golterman (ed.), Interactions between sediments and freshwater. pp. 343-347., (1977)
Computer:	211, Jorgensen S.E., Ecol. Modell. 16:99-124., (1982)
	244, Jorgensen S.E., In: H.L. Golterman (ed.), Interactions between sediments and freshwater. pp. 387-389., (1977)

Total P:

Description:	97, Koerselman W., Landschap 10(4):31-44. (in Dutch), (1993)
	100, Golterman H.L., Avan. Oceanol. Med. Bull. Inst. Oceanogr. Mon. Spec. 11:75-87., (1992)
	122, Malmer N., Bot. Not. 111:274-283., (1958)
	242, Arts G.H.P., Freshwater Biol. 24:287-294., (1990)
	245, Ahlgren I., In: H.L. Golterman (ed.), Interactions between sediments and freshwater. pp. 372-377., (1977)
Lab:	6, Groot C.J. de, Hydrobiologia 192:143-148., (1990)
	216, Rippey B., In: H.L. Golterman (ed.), Interactions between sediments and freshwater. pp. 348-353., (1977)
	251, Golterman H.L., In: H.L. Golterman (ed.), Interactions between sediments and freshwater. pp. 286-293., (1977)
Field:	53, Sonesson M. (ed.), Swedish Natural Science Research Council, Ecological Bulletins 30. 313 pp., (1980)
	70, Hillbricht-Ilkowska A., Hydrobiologia 251:257-268., (1993)
	147, Kaila A., J. Sci. Agric. Soc. Finland 28:142-167., (1956)
	197, Olsson H., Vatten 47:263-272. (in Swedish, English abstract)., (1991)
	247, Kamp-Nielsen L., In: H.L. Golterman (ed.), Interactions between sediments and freshwater. pp. 277-285., (1977)
	249, Stevens R.J., In: H.L. Golterman (ed.), Interactions between sediments and freshwater. pp. 343-347., (1977)
	275, Pieczynska E., Ekol. Pol. 32:387-440., (1984)
	280, Sarvala J., Hydrobiologia 86:41-53., (1982)
	292, Gunatilaka A., Arch. Hydrobiol. Beih. Ergebn. Limnol. 30:15-24., (1988)
	300, Vermeer H.J.G., The Utrecht Plant Ecology News Report 2:8-17. (in Dutch, English abstract), (1985)
Computer:	211, Jorgensen S.E., Ecol. Modell. 16:99-124., (1982)

P cycling:

Description:	38, Ostendorp W., Telma 18:351-372. (in German, English abstract), (1988)
	50, Lijklema L., In: H.L. Golterman (ed.), Interactions between sediments and freshwater. pp. 313-317., (1977)
	60, Koerselman W., Ph.D. Thesis University of Utrecht. 164 pp., (1989)
	77, Hosper S.H., The Utrecht Plant Ecology News Report 11:130-146 / Hydrobiologia 200/201:523-533., (1990)
	79, Lijklema L., The Utrecht Plant Ecology News Report 11:44-51., (1990)
	80, Verhoeven J.T.A., The Utrecht Plant Ecology News Report 11:5-21. (in Dutch, English summary), (1990)
	98, Andersson G., Hydrobiologia 170:267-284., (1988)
	100, Golterman H.L., Avan. Oceanol. Med. Bull. Inst. Oceanogr. Mon. Spec. 11:75-87., (1992)
	297, Boström B., Arch. Hydrobiol. Beih. Ergebn. Limnol. 18:5-59., (1982)
	306, Denny P., Arch. Hydrobiol. Beih. Ergebn. Limnol. 27:1-25., (1987)
Lab:	49, Groot C.J. de, Verh. Int. Ver. Limnol. 24:3029-3035., (1991)
	89, Jansson M., In: P.G. Sly (ed.), Sediments and water interactions. Springer-Verlag, New York. pp. 387-389., (1986)
	101, Kristensen E., J. Exp. Mar. Biol. Ecol. 75:171-190., (1984)
Field:	32, Brock Th.C.M., Aquat. Bot. 17:189-214., (1983)
	53, Sonesson M. (ed.), Swedish Natural Science Research Council, Ecological Bulletins 30. 313 pp., (1980)
	58, Saebo S., Meld. Norges Landbrukshögsk. 47. 67 pp., (1968)
	70, Hillbricht-Ilkowska A., Hydrobiologia 251:257-268., (1993)
	82, Verhoeven J.T.A., Oecologia 72:557-561., (1987)
	170, Kaila A., J. Sci. Agric. Soc. Finland 28:90-104., (1956)
	198, Egloff Th., Ber. Geobot. Inst. ETH, Stiftung Rübel 50:119-148. (in German, English abstract), (1983)
	231, Henriksen K., Neth. Inst. Sea Res. Publ. Ser. 10:51-69., (1984)
	275, Pieczynska E., Ekol. Pol. 32:387-440., (1984)
Computer:	91, Eck G.Th.M. van, In: P.G. Sly (ed.), Sediments and water interactions. Springer-Verlag, New York. pp. 189-301., (1986)
	211, Jorgensen S.E., Ecol. Modell. 16:99-124., (1982)
	247, Kamp-Nielsen L., In: H.L. Golterman (ed.), Interactions between sediments and freshwater. pp. 277-285., (1977)
	311, Jorgensen S.E., In: W.J. Mitsch et al. (eds.), Wetland modelling. pp. 133-151., (1988)

3.6 Fe and Mn-transformations

Table 8: The processes extracted from the "Matrix of Information on Wetland Processes" referred to in this section. For each process/category combination the number of relevant european literature records is indicated. The total can be smaller than the sum, due to references addressing more processes/categories.

Process	Description	Lab	Field	Computer
Fe Transformations	6	X	X	X
Ferrous Iron	1	5	1	0
Soil color	0	0	0	0
Mn Transformations	3	X	X	X
Manganous Mn	1	2	0	0
Total	7	5	1	0

In total 13 literature records regarding "Fe and Mn-transformations" have been selected and reviewed.

Reduction of manganese and iron to manganous Mn and ferrous Fe is an important proces in anoxic wetland soils, leading to reduced P-fluxes (e.g. record 49) and nitrification (e.g. record 83). Moreover Fe and Mn are more available for plant uptake under reduced conditions. Reduced Fe and Mn are measured using specific complexation agents (e.g. records 226 and 227). Manganous Mn is only studied in combination with ferrous iron.

Fe Transformations:

Description:	50, Lijklema L., In: H.L. Golterman (ed.), Interactions between sediments and freshwater. pp. 313-317., (1977)
	52, Sly P.G. (ed.), Proceedings of the Third International Symposium on Interactions Between Sediments and Water, (1986)
	80, Verhoeven J.T.A., The Utrecht Plant Ecology News Report 11:5-21. (in Dutch, English summary), (1990)
	118, Jones H.E., J. Ecol. 58:487-496., (1970)
	120, Best E.P.H., Developments in Hydrobiology 88. Kluwer Academic Publishers, Dordrecht. - Hydrobiologia 265., (1993)
	201, Armstrong W., In: J.R. Etherington (ed.), Environmental plant ecology. 2nd ed. pp. 290-330., (1982)

Ferrous iron:

Description:	287, Janiesch P., In: J. Rozema & J.A.C. Verkleij (eds.), Ecological responses to environmental stresses. pp. 50-60., (1991)
Lab:	49, Groot C.J. de, Verh. Int. Ver. Limnol. 24:3029-3035., (1991)
	83, Golterman H.L., Verh. Int. Ver. Limnol. 24:3025-3028., (1991)
	145, Rozema J., Vegetatio 62:293-301., (1985)
	226, P.E.J. Laan, Ph.D. Thesis, University of Nijmegen., (1990)
	227, Diggelen J. van, Ph.D. Thesis, Free University Amsterdam., (1988)
Field:	250, Jorgensen B.B., Limnol. Oceanogr. 22:814-832., (1977)

Mn Transformations:

Description:	52, Sly P.G. (ed.), Proceedings of the Third International Symposium on Interactions Between Sediments and Water, (1986)
	118, Jones H.E., J. Ecol. 58:487-496., (1970)
	201, Armstrong W., In: J.R. Etherington (ed.), Environmental plant ecology. 2nd ed. pp. 290-330., (1982)

Manganous Mn:

Description:	287, Janiesch P., In: J. Rozema & J.A.C. Verkleij (eds.), Ecological responses to environmental stresses. pp. 50-60., (1991)
Lab:	145, Rozema J., Vegetatio 62:293-301., (1985)
	227, Diggelen J. van, Ph.D. Thesis, Free University Amsterdam., (1988)

3.7 Toxicant-transformations

Table 9: The processes extracted from the "Matrix of Information on Wetland Processes" referred to in this section. For each process/category combination the number of relevant european literature records is indicated. The total can be smaller than the sum, due to references addressing more processes/categories.

Process	Description	Lab	Field	Computer
Metal Transformation	3	0	3	0

Only 6 literature records regarding "toxicant-transformations" have been selected and reviewed. These records deal with metal speciation and various metal complexes, of different species and complexing agents, in relation to bioaccumulation of metals in marsh plants and subsequent growth reduction (e.g. record 158). No studies on degradation of organic toxicants in wetland soils have been selected. It is, however, known that the degradation of organic toxicants is relatively slow in inorganic, wet soils.

Metal Transormations:

Description:	52, Sly P.G. (ed.), Proceedings of the Third International Symposium on Interactions Between Sediments and Water, (1986)
	113, Schot P.P., Ph.D. Thesis University of Utrecht., (1991)
	120, Best E.P.H., Developments in Hydrobiology 88. Kluwer Academic Publishers, Dordrecht. - Hydrobiologia 265., (1993)
Field:	158, Rozema J., Proc. Int. Conf. Heavy metals in the environment, Athens 1985., (1985)
	229, Otte M.R., Ph.D. Thesis, Free University Amsterdam., (1991)
	254, Otte M.L., Environ. Pollut. 82:13-22., (1993)

3.8 Sediment/Water exchange

Table 10: The processes extracted from the "Matrix of Information on Wetland Processes" referred to in this section. For each process/category combination the number of relevant european literature records is indicated. The total can be smaller than the sum, due to references addressing more processes/categories.

Process	Description	Lab	Field	Computer
Sediment/Water Exchange	16	16	24	5

In total 56 literature records regarding "sediment/water exchange" have been selected and reviewed. All these studies are related to the flux of inorganic nutrients or toxicants from wetland sediments into surface water or biota. Fluxes of nutrients are measured from the change in concentration in above standing water during incubation of flux chambers (e.q. records 136, 237, 284), flow through systems (e.g. records 294 and 316), or a depth profile of different nutrient species in sediment cores (e.g. records 16 and 168). Methods are described in more detail in paragraphs 3.2-3.5.
Fluxes of toxicants are generally measured from the bioaccumulation in plants (see paragraph 4.3) or fauna. Some records (36, 95, 192, 216) are dealing with the influence of faunal bioturbation on the release of nutrients and toxicants from soils (see also paragraph 4.7).

A different approach is incubation of bags with peat material followed by analysis of changes in chemical composition (viz. records 218, 258). The sediment-water exchanges are also calculated from budget studies (e.g. records 249, 280).

Sed. / water exchange:

Description:	25, Leonardson L., Vatten 48:221-230. (in Swedish, English abstract), (1992)
	47, Bernaldez F.G., Geoderma 55:273-288., (1992)
	52, Sly P.G. (ed.), Proceedings of the Third International Symposium on Interactions Between Sediments and Water, (1986)
	78, Koerselman W., The Utrecht Plant Ecology News Report 11:22-43. (in Dutch, English summary), (1990)
	79, Lijklema L., The Utrecht Plant Ecology News Report 11:44-51., (1990)
	80, Verhoeven J.T.A., The Utrecht Plant Ecology News Report 11:5-21. (in Dutch, English summary), (1990)
	84, Winter M., The Utrecht Plant Ecology News Report 4:123-140., (1985)
	101, Kristensen E., J. Exp. Mar. Biol. Ecol. 75:171-190., (1984)
	104, Pelegri S.P., Mar. Ecol. Prog. Ser. 105:285-290., (1994)
	105, Jansson M., Ambio 23:320-325., (1994)
	106, Vought L.B.M., Ambio 23:342-348., (1994)
	113, Schot P.P., Ph.D. Thesis University of Utrecht., (1991)
	115, Meuleman A.F.M., The Utrecht Plant Ecology News Report 10:23-38. (in Dutch), (1990)
	117, Oorschot M.M.P. van, The Utrecht Plant Ecology News Report 11:64-85. (in Dutch, English abstract), (1990)
	297, Boström B., Arch. Hydrobiol. Beih. Ergebn. Limnol. 18:5-59., (1982)
	306, Denny P., Arch. Hydrobiol. Beih. Ergebn. Limnol. 27:1-25., (1987)
Lab:	33, Cuttle S.P., J. Soil Sci. 34:75-82., (1983)
	36, Marquenie J.M., TNO report V14, Den Helder., (1985)
	85, Koerselman W., Biogeochemistry 20:63-81., (1993)
	88, Klapwijk S.P., In: P.G. Sly (ed.), Sediments and water interactions. Springer-Verlag, New York. pp. 391-398., (1986)
	95, Marquenie J.M., TNO report R85/075., (1985)
	137, Henriksen K., Mar. Biol. 61:299-304., (1981)
	192, Regnault M., Cah. Biol. Mar. 29:427-444., (1988)
	216, Rippey B., In: H.L. Golterman (ed.), Interactions between sediments and freshwater. pp. 348-353., (1977)
	217, Banoub M.W., In: H.L. Golterman (ed.), Interactions between sediments and freshwater. pp. 324-330., (1977)
	248, Abdollahi H., Microbial Ecol. 5:73-79., (1979)
	251, Golterman H.L., In: H.L. Golterman (ed.), Interactions between sediments and freshwater. pp. 286-293., (1977)
	284, Ambus P., Soil Sci. Soc. Am. J. 55:994-997., (1991)
	288, Scholten M.C.Th., TNO report R94/073., (1994)
	289, Scholten M.C.Th., TNO report R94/049., (1994)
	294, Rysgaard S., Limnol. Oceanogr. 39:1643-1652., (1994)
	316, Pelegri S.P., Mar. Biol. 121:253-258., (1994)

Sed. / water exchange:

Field:	9, Forès E., Mar. Ecol. Prog. Ser. 106:283-290., (1994)
	11, Haycock N.E., Hydrol. Process. 7:287-295., (1993)
	16, Pakarinen P., Lindbergia 4:27-33., (1977)
	41, Leonardson L., Vatten 47:315-316., (1991)
	53, Sonesson M. (ed.), Swedish Natural Science Research Council, Ecological Bulletins 30. 313 pp., (1980)
	60, Koerselman W., Ph.D. Thesis University of Utrecht. 164 pp., (1989)
	62, Koerselman W., J. Ecol. 78:428-442., (1990)
	92, Damiani V., In: P.G. Sly (ed.), Sediments and water interactions. Springer-Verlag, New York. pp. 13-25., (1986)
	136, Hall P.O.J., Limnol. Oceanogr. 34:734-746., (1989)
	168, Kivekäs J., J. Sci. Agric. Soc. Finland 29:41-55., (1957)
	218, Granéli W., In: H.L. Golterman (ed.), Interactions between sediments and freshwater. pp. 276., (1977)
	219, Ryding S.O., In: H.L. Golterman (ed.), Interactions between sediments and freshwater. pp. 227-234., (1977)
	223, Sallantaus T., Suo 43:253-258., (1992)
	237, Tirén T., In: H.L. Golterman (ed.), Interactions between sediments and freshwater.pp. 363-369., (1977)
	245, Ahlgren I., In: H.L. Golterman (ed.), Interactions between sediments and freshwater. pp. 372-377., (1977)
	247, Kamp-Nielsen L., In: H.L. Golterman (ed.), Interactions between sediments and freshwater. pp. 277-285., (1977)
	248, Abdollahi H., Microbial Ecol. 5:73-79., (1979)
	249, Stevens R.J., In: H.L. Golterman (ed.), Interactions between sediments and freshwater. pp. 343-347., (1977)
	256, Reinikainen A., Ann. Bot. Fennici 21:79-101., (1984)
	258, Abd.Aziz S.A., Est. Coast. Shelf Sci. 22:689-704., (1986)
	280, Sarvala J., Hydrobiologia 86:41-53., (1982)
	282, Clymo R.S., J. Ecol. 53:747-757., (1965)
	285, Grootjans A.P., Acta Oecol. Oecol. Plant. 6:403-417., (1985)
	289, Scholten M.C.Th., TNO report R94/049., (1994)
Computer:	9, Forès E., Mar. Ecol. Prog. Ser. 106:283-290., (1994)
	91, Eck G.Th.M. van, In: P.G. Sly (ed.), Sediments and water interactions. Springer-Verlag, New York. pp. 189-301., (1986)
	136, Hall P.O.J., Limnol. Oceanogr. 34:734-746., (1989)
	244, Jorgensen S.E., In: H.L. Golterman (ed.), Interactions between sediments and freshwater. pp. 387-389., (1977)
	247, Kamp-Nielsen L., In: H.L. Golterman (ed.), Interactions between sediments and freshwater. pp. 277-285., (1977)

4. BIOLOGY OF WETLANDS

4.1 General introduction

Wetland biota have to tolerate extreme soil conditions, viz. anoxia, immersion or submersion and (in the case of coastal wetlands) salinity. Reduced soil conditions are not only experienced as anoxia, but also as a loss of inorganic nitrogen, as toxicity of Mn^{2+} and S^{2-}, or as altered biomobility of soil bound toxicants. On the other hand, wetland flora and fauna influence soil chemistry by rooting or bioturbation respectively.

Under productive conditions wetland macrophyte vegetation or macroalgae contribute substantially to the element cycling within a wetland.

Biological response measurements can be used for the control of the actual wetland functioning.

4.2 Microbiology

Table 11: The processes extracted from the "Matrix of Information on Wetland Processes" referred to in this section. For each process/category combination the number of relevant european literature records is indicated. The total can be smaller than the sum, due to references addressing more processes/categories.

Process	Description	Lab	Field	Computer
Microbial	15	5	12	2

In total 29 literature records regarding "microbiology" have been selected and reviewed. Most of the records are dealing with N-transformations in wetland soils (see section 3.2) or decomposition of organic matter (e.g. records 1, 19, 68, 308; see also section 3.4) In records 21 and 220, methods are presented which can be used to characterize microbial populations from wetland soils. Microbial activity is measured on the basis of O_2 respiration (e.g. record 136) or enzyme activity (e.g. record 233). Record 193 presents a series of microbiological methods, including the measurement of microbial cell constituents released by fumigation, measurement of specific cellwall aminoacids, and biomass estimates from ergosterol concentrations.

Microbial:

Description:

1, Verhoeven J.T.A., J. Ecol. 78:713-726., (1990)

11, Haycock N.E., Hydrol. Process. 7:287-295., (1993)

52, Sly P.G. (ed.), Proceedings of the Third International Symposium on Interactions Between Sediments and Water, (1986)

68, Malmer N., In: M. Sonesson (ed.), Ecology of a subarctic mire. Ecological Bulletins (Stockholm) 30:63-95., (1980)

78, Koerselman W., The Utrecht Plant Ecology News Report 11:22-43. (in Dutch, English summary), (1990)

99, Jansson M., Hydrobiologia 170:177-189., (1988)

105, Jansson M., Ambio 23:320-325., (1994)

110, Ahlgren I., Ambio 23:367-377., (1994)

117, Oorschot M.M.P. van, The Utrecht Plant Ecology News Report 11:64-85. (in Dutch, English abstract), (1990)

	185, Armentano T.V., In: B.C. Patten & S.E. Jorgensen (eds.), Wetlands and shallow water bodies. pp. 281-311., (1990) 235, Alkemade R., Mar. Ecol. Prog. Ser. 99:293-300., (1993) 241, Andersen J.M., In: H.L. Golterman (ed.), Interactions between sediments and freshwater. pp. 357-362., (1977) 281, Granhall U., Physiol. Plant. 36:88-94., (1976) 308, Imhof G., Pol. Arch. Hydrobiol. 20:165-168., (1973) 316, Pelegri S.P., Mar. Biol. 121:253-258., (1994)
Lab:	4, Buth G.J.C., In: J.T.A. Verhoeven et al. (eds.), Vegetation structure in relation to carbon and nutrient economy. pp. 51-60., (1988) 20, Martin N.J., In: O.W. Heal & D.F. Perkins (eds.), Production ecology of British moors and montane grasslands. pp. 113-135., (1978) 21, Collins V.G., In: O.W. Heal & D.F. Perkins (eds.), Production ecology of British moors and montane grasslands. pp. 94-112., (1978) 59, Gerlach A., Scripta Geobotanica 5. 115 pp. (in German, English abstract), (1973) 217, Banoub M.W., In: H.L. Golterman (ed.), Interactions between sediments and freshwater. pp. 324-330., (1977)
Field:	4, Buth G.J.C., In: J.T.A. Verhoeven et al. (eds.), Vegetation structure in relation to carbon and nutrient economy. pp. 51-60., (1988) 19, Heal O.W., In: O.W. Heal & D.F. Perkins (eds.), Production ecology of British moors and montane grasslands. pp. 136-159., (1978) 20, Martin N.J., In: O.W. Heal & D.F. Perkins (eds.), Production ecology of British moors and montane grasslands. pp. 113-135., (1978) 21, Collins V.G., In: O.W. Heal & D.F. Perkins (eds.), Production ecology of British moors and montane grasslands. pp. 94-112., (1978) 53, Sonesson M. (ed.), Swedish Natural Science Research Council, Ecological Bulletins 30. 313 pp., (1980) 59, Gerlach A., Scripta Geobotanica 5. 115 pp. (in German, English abstract), (1973) 136, Hall P.O.J., Limnol. Oceanogr. 34:734-746., (1989) 193, Karsisto M., Suo 43:217-220., (1992) 220, Mannerkoski H., In: Proceedings of the 4th international peat congress, Finland, 1972. Vol. 1. pp. 319-326., (1972) 233, Wainwright M., Plant Soil 59:357-363., (1979) 248, Abdollahi H., Microbial Ecol. 5:73-79., (1979) 258, Abd.Aziz S.A., Est. Coast. Shelf Sci. 22:689-704., (1986)
Computer:	93, Svenssen B.H., In: M. Sonesson (ed.), Ecology of a subarctic mire. Ecological Bulletins (Stockholm) 30:283-301., (1980) 136, Hall P.O.J., Limnol. Oceanogr. 34:734-746., (1989)

4.3 Element cycles through vegetation

Table 12: The processes extracted from the "Matrix of Information on Wetland Processes" referred to in this section. For each process/category combination the number of relevant european literature records is indicated. The total can be smaller than the sum, due to references addressing more processes/categories.

Process	Description	Lab	Field	Computer
Uptake & Cycling	13	X	X	X
Nitrogen	16	12	49	3
Phosphorus	11	8	34	2
Potassium	6	6	21	0
Metals	1	4	10	0
Organics	1	0	1	0
Total	31	17	59	3

In total 104 literature records regarding "element cycles through vegetation" have been selected and reviewed. Most of these studies are related to the assimilation of N and P in plant biomass (and subsequent production rates) under various conditions, as part of the nutrient dynamics in wetlands (see record 72 for a review). A number of, mainly Dutch, studies is dealing with the removal of N and P from surface waters by means of wetland vegetation. Such helophyte filters are recently applied in waste water treatment in the Netherlands. Record 80 gives a review of the general principle, while record 78 presents methods to measure the N and P removal efficiency of helophyte filters.

The measurement of the concentrations of Fe and Mn in plants is related to estimate the sensitivity of plant species to inundation (e.g. records 118, 145). Tolerant species can inhibit the uptake of the ready bioavailable manganous and ferrous fractions. A few records (229,

254, 257) are dealing with metal accumulation in marsh plants, grown under various conditions in the field.

Emergent vegetation:

Uptake and cycling:

Description:

53, Sonesson M. (ed.), Swedish Natural Science Research Council, Ecological Bulletins 30. 313 pp., (1980)

72, Pieczynska E., Hydrobiologia 251:49-58., (1993)

80, Verhoeven J.T.A., The Utrecht Plant Ecology News Report 11:5-21. (in Dutch, English summary), (1990)

118, Jones H.E., J. Ecol. 58:487-496., (1970)

120, Best E.P.H., Developments in Hydrobiology 88. Kluwer Academic Publishers, Dordrecht. - Hydrobiologia 265., (1993)

185, Armentano T.V., In: B.C. Patten & S.E. Jorgensen (eds.), Wetlands and shallow water bodies. pp. 281-311., (1990)

186, Damman A.W.H., Suo 43:137-145., (1992)

255, Lefeuvre J.C., EEC Contract EV4V-0172-F (EDB). 258 pp., (1993)

266, Rijs G.B.J., The Utrecht Plant Ecology News Report 11:147-166. (in Dutch, English summary), (1990)

267, Maeseneer J. de, The Utrecht Plant Ecology News Report 4:141-148. (in Dutch, English Abstract), (1985)

271, Meuleman A.F.M., The Utrecht Plant Ecology News Report 11:167-187. (in Dutch, English summary), (1990)

272, Fiselier J.L., The Utrecht Plant Ecology News Report 11:225-246. (in Dutch, English summary), (1990)

310, Logofet D.O., In: W.J. Mitsch et al. (eds.), Wetland modelling. pp. 55-66., (1988)

Nitrogen:

Description:

78, Koerselman W., The Utrecht Plant Ecology News Report 11:22-43. (in Dutch, English summary), (1990)

100, Golterman H.L., Avan. Oceanol. Med. Bull. Inst. Oceanogr. Mon. Spec. 11:75-87., (1992)

102, Hemminga M.A., Mar. Ecol. Prog. Ser. 71:85-96., (1991)

105, Jansson M., Ambio 23:320-325., (1994)

106, Vought L.B.M., Ambio 23:342-348., (1994)

117, Oorschot M.M.P. van, The Utrecht Plant Ecology News Report 11:64-85. (in Dutch, English abstract), (1990)

122, Malmer N., Bot. Not. 111:274-283., (1958)

124, Dijk H.W.J. van, Acta Bot. Neerl. 34:301-319., (1985)

183, Verhoeven J.T.A., Aquat. Bot. 25:117-137., (1986)

191, Fleischer S., Ambio 20:271-272., (1991)

252, Jauhiainen J., Suo 43:211-215., (1992)

263, Lee J.A., In: J.T.A. Verhoeven et al. (eds.), Vegetation structure in relation to carbon and nutrient economy. pp. 137-147., (1988)

	269, Greiner R.W., The Utrecht Plant Ecology News Report 4:39-63. (in Dutch, English Abstract), (1985) 270, Duel H., The Utrecht Plant Ecology News Report 11:188-202. (in Dutch, English summary), (1990) 278, Leendertse P., Report Free University, Amsterdam. (in Dutch), (1992) 306, Denny P., Arch. Hydrobiol. Beih. Ergebn. Limnol. 27:1-25., (1987)
Lab:	4, Buth G.J.C., In: J.T.A. Verhoeven et al. (eds.), Vegetation structure in relation to carbon and nutrient economy. pp. 51-60., (1988) 14, Loach K., J. Ecol. 56:117-127., (1968) 31, Basilier K., Oikos 34:239-242., (1980) 57, Saebo S., Meld. Norges Landbrukshögsk. 49. 37 pp., (1970) 151, Schat H., Acta Oecol. Oecol. Plant. 5:119-131., (1984) 164, Jensen A., Vegetatio 61:231-240., (1985) 169, Koncalova H., Wetl. Ecol. Manage. 2:199-211., (1993) 172, Jefferies R.L., J. Ecol. 65:847-865., (1977) 177, Stewart G.R., In: R.I. Jefferies & A.J. Davy (eds.), Ecological processes in the coastal environments. pp. 211-227, (1977) 227, Diggelen J. van, Ph.D. Thesis, Free University Amsterdam., (1988) 276, Karman C.C., Report Free University, Amsterdam. (in Dutch), (1992) 288, Scholten M.C.Th., TNO report R94/073., (1994)
Field:	1, Verhoeven J.T.A., J. Ecol. 78:713-726., (1990) 2, Waughman G.J., J. Ecol. 68:1025-1046., (1980) 4, Buth G.J.C., In: J.T.A. Verhoeven et al. (eds.), Vegetation structure in relation to carbon and nutrient economy. pp. 51-60., (1988) 9, Forès E., Mar. Ecol. Prog. Ser. 106:283-290., (1994) 12, Knauer N., Z. Kulturtechn. Landentw. 30:365-376. (in German, English abstract), (1989) 13, Koutler-Andersson E., Kungl. Lantbrukshögsk. Ann. 26:33-40., (1960) 14, Loach K., J. Ecol. 56:117-127., (1968) 15, Pakarinen P., Ann. Bot. Fennici 15:15-26., (1978) 16, Pakarinen P., Lindbergia 4:27-33., (1977) 24, Klötzli F., Giorn. Bot. Ital. 121:101-120. (in French, English abstract), (1987) 29, Verhoeven J.T.A., Oecologia 60:25-33., (1983) 32, Brock Th.C.M., Aquat. Bot. 17:189-214., (1983) 37, Malmer N., Bot. Not. 108:46-80., (1955) 38, Ostendorp W., Telma 18:351-372. (in German, English abstract), (1988) 39, Dykyjova D., Ecological Studies 28. Springer-Verlag, Berlin. 464 pp., (1978) 41, Leonardson L., Vatten 47:315-316., (1991) 42, Durka W., Nature 372:765-767., (1994) 45, Brock Th.C.M., Oecologia 80:44-52., (1989) 48, Heckman C.W., Aquat. Bot. 25:139-151., (1986) 57, Saebo S., Meld. Norges Landbrukshögsk. 49. 37 pp., (1970) 60, Koerselman W., Ph.D. Thesis University of Utrecht. 164 pp., (1989) 62, Koerselman W., J. Ecol. 78:428-442., (1990)

68, Malmer N., In: M. Sonesson (ed.), Ecology of a subarctic mire. Ecological Bulletins (Stockholm) 30:63-95., (1980)

73, Donk E. van, Hydrobiologia 251:19-26., (1993)

74, Kühl H., Hydrobiologia 251:1-12., (1993)

76, Gorham E., J. Ecol. 41:345-360., (1953)

81, Tamm C.O., Oikos 5:189-194., (1954)

82, Verhoeven J.T.A., Oecologia 72:557-561., (1987)

107, Fleischer S., Ambio 23:349-357., (1994)

108, Jacks G., Ambio 23:358-362., (1994)

109, Weisner S.E.B., Ambio 23:363-366., (1994)

112, Wassen M.J., Ph.D. Thesis University of Utrecht., (1990)

119, Koerselman W., In: J.T.A. Verhoeven (ed.), Fens and bogs in the Netherlands: pp. 397-432., (1992)

125, Aerts R., Vegetatio 76:63-69., (1988)

126, Aerts R., J. Ecol. 80:131-140., (1992)

167, Mattson S., Kungl. Landbrukshögsk. Ann. 12:186-203. [Ann. Agric. Coll. Sweden], (1944)

171, Jefferies R.L., J. Ecol. 65:867-882., (1977)

173, Stewart G.R., New Phytol. 72:539-546., (1973)

174, Abd.Aziz S.A., In: R.I. Jefferies & A.J. Davy (eds.), Ecological processes in the coastal environments. pp. 385-398., (1979)

178, Pigott C.D., In: I.H. Rorison (ed.), Ecological aspects of the mineral nutrition of plants. pp. 25-35., (1969)

261, Linden M.J.H.A. van der, Acta Oecol. Oecol. Plant. 1:219-230., (1980)

262, Kühl H., Int. Rev. Ges. Hydrobiol. 77:85-107., (1992)

279, Gudde L., The Utrecht Plant Ecology News Report 2:46-52. (in Dutch, English abstract), (1985)

280, Sarvala J., Hydrobiologia 86:41-53., (1982)

285, Grootjans A.P., Acta Oecol. Oecol. Plant. 6:403-417., (1985)

300, Vermeer H.J.G., The Utrecht Plant Ecology News Report 2:8-17. (in Dutch, English abstract), (1985)

303, Malmer N., Aquilo Ser. Bot. 28:57-65., (1990)

305, Vermeer J.G., Acta Oecol. Oecol. Plant. 7:31-41., (1986)

313, Jónsdóttir I.S., Sci. Total Environ. 160/161:677-685., (1995)

Computer:

9, Forès E., Mar. Ecol. Prog. Ser. 106:283-290., (1994)

311, Jorgensen S.E., In: W.J. Mitsch et al. (eds.), Wetland modelling. pp. 133-151., (1988)

312, Straskraba M., In: W.J. Mitsch et al. (eds.), Wetland modelling. pp. 153-175., (1988)

Phosphorus:

Description:

78, Koerselman W., The Utrecht Plant Ecology News Report 11:22-43. (in Dutch, English summary), (1990)

100, Golterman H.L., Avan. Oceanol. Med. Bull. Inst. Oceanogr. Mon. Spec. 11:75-87., (1992)

114, Kemmers R.H., The Utrecht Plant Ecology News Report 10:7-22. (in Dutch, English Abstract), (1990)

117, Oorschot M.M.P. van, The Utrecht Plant Ecology News Report 11:64-85. (in Dutch, English abstract), (1990)

	122, Malmer N., Bot. Not. 111:274-283., (1958)
	124, Dijk H.W.J. van, Acta Bot. Neerl. 34:301-319., (1985)
	183, Verhoeven J.T.A., Aquat. Bot. 25:117-137., (1986)
	268, Butijn G.D., The Utrecht Plant Ecology News Report 4:64-90. (in Dutch, English Abstract), (1985)
	269, Greiner R.W., The Utrecht Plant Ecology News Report 4:39-63. (in Dutch, English Abstract), (1985)
	278, Leendertse P., Report Free University, Amsterdam. (in Dutch), (1992)
	306, Denny P., Arch. Hydrobiol. Beih. Ergebn. Limnol. 27:1-25., (1987)
Lab:	14, Loach K., J. Ecol. 56:117-127., (1968)
	28, Veerkamp M.T., Physiol. Plant. 50:237-240., (1980)
	58, Saebo S., Meld. Norges Landbrukshögsk. 47. 67 pp., (1968)
	145, Rozema J., Vegetatio 62:293-301., (1985)
	151, Schat H., Acta Oecol. Oecol. Plant. 5:119-131., (1984)
	169, Koncalova H., Wetl. Ecol. Manage. 2:199-211., (1993)
	227, Diggelen J. van, Ph.D. Thesis, Free University Amsterdam., (1988)
	288, Scholten M.C.Th., TNO report R94/073., (1994)
Field:	1, Verhoeven J.T.A., J. Ecol. 78:713-726., (1990)
	2, Waughman G.J., J. Ecol. 68:1025-1046., (1980)
	8, Verhoeven J.T.A., Biogeochemistry 6:31-43., (1988)
	12, Knauer N., Z. Kulturtechn. Landentw. 30:365-376. (in German, English abstract), (1989)
	14, Loach K., J. Ecol. 56:117-127., (1968)
	15, Pakarinen P., Ann. Bot. Fennici 15:15-26., (1978)
	16, Pakarinen P., Lindbergia 4:27-33., (1977)
	24, Klötzli F., Giorn. Bot. Ital. 121:101-120. (in French, English abstract), (1987)
	29, Verhoeven J.T.A., Oecologia 60:25-33., (1983)
	32, Brock Th.C.M., Aquat. Bot. 17:189-214., (1983)
	37, Malmer N., Bot. Not. 108:46-80., (1955)
	38, Ostendorp W., Telma 18:351-372. (in German, English abstract), (1988)
	39, Dykyjova D., Ecological Studies 28. Springer-Verlag, Berlin. 464 pp., (1978)
	45, Brock Th.C.M., Oecologia 80:44-52., (1989)
	48, Heckman C.W., Aquat. Bot. 25:139-151., (1986)
	58, Saebo S., Meld. Norges Landbrukshögsk. 47. 67 pp., (1968)
	60, Koerselman W., Ph.D. Thesis University of Utrecht. 164 pp., (1989)
	62, Koerselman W., J. Ecol. 78:428-442., (1990)
	68, Malmer N., In: M. Sonesson (ed.), Ecology of a subarctic mire. Ecological Bulletins (Stockholm) 30:63-95., (1980)
	73, Donk E. van, Hydrobiologia 251:19-26., (1993)
	81, Tamm C.O., Oikos 5:189-194., (1954)
	82, Verhoeven J.T.A., Oecologia 72:557-561., (1987)
	112, Wassen M.J., Ph.D. Thesis University of Utrecht., (1990)

	119, Koerselman W., In: J.T.A. Verhoeven (ed.), Fens and bogs in the Netherlands: pp. 397-432., (1992)
	125, Aerts R., Vegetatio 76:63-69., (1988)
	126, Aerts R., J. Ecol. 80:131-140., (1992)
	167, Mattson S., Kungl. Landbrukshögsk. Ann. 12:186-203. [Ann. Agric. Coll. Sweden], (1944)
	178, Pigott C.D., In: I.H. Rorison (ed.), Ecological aspects of the mineral nutrition of plants. pp. 25-35., (1969)
	279, Gudde L., The Utrecht Plant Ecology News Report 2:46-52. (in Dutch, English abstract), (1985)
	280, Sarvala J., Hydrobiologia 86:41-53., (1982)
	292, Gunatilaka A., Arch. Hydrobiol. Beih. Ergebn. Limnol. 30:15-24., (1988)
	300, Vermeer H.J.G., The Utrecht Plant Ecology News Report 2:8-17. (in Dutch, English abstract), (1985)
	303, Malmer N., Aquilo Ser. Bot. 28:57-65., (1990)
	305, Vermeer J.G., Acta Oecol. Oecol. Plant. 7:31-41., (1986)
Computer:	311, Jorgensen S.E., In: W.J. Mitsch et al. (eds.), Wetland modelling. pp. 133-151., (1988)
	312, Straskraba M., In: W.J. Mitsch et al. (eds.), Wetland modelling. pp. 153-175., (1988)

Potassium:

Description:	117, Oorschot M.M.P. van, The Utrecht Plant Ecology News Report 11:64-85. (in Dutch, English abstract), (1990)
	122, Malmer N., Bot. Not. 111:274-283., (1958)
	124, Dijk H.W.J. van, Acta Bot. Neerl. 34:301-319., (1985)
	183, Verhoeven J.T.A., Aquat. Bot. 25:117-137., (1986)
	268, Butijn G.D., The Utrecht Plant Ecology News Report 4:64-90. (in Dutch, English Abstract), (1985)
	306, Denny P., Arch. Hydrobiol. Beih. Ergebn. Limnol. 27:1-25., (1987)
Lab:	14, Loach K., J. Ecol. 56:117-127., (1968)
	151, Schat H., Acta Oecol. Oecol. Plant. 5:119-131., (1984)
	169, Koncalova H., Wetl. Ecol. Manage. 2:199-211., (1993)
	204, Cooper A., New Phytol. 90:263-275., (1982)
	227, Diggelen J. van, Ph.D. Thesis, Free University Amsterdam., (1988)
	288, Scholten M.C.Th., TNO report R94/073., (1994)
Field:	2, Waughman G.J., J. Ecol. 68:1025-1046., (1980)
	10, Gies T., Flora 162:244-268. (in German, English abstract), (1973)
	14, Loach K., J. Ecol. 56:117-127., (1968)
	15, Pakarinen P., Ann. Bot. Fennici 15:15-26., (1978)
	16, Pakarinen P., Lindbergia 4:27-33., (1977)
	29, Verhoeven J.T.A., Oecologia 60:25-33., (1983)
	37, Malmer N., Bot. Not. 108:46-80., (1955)
	39, Dykyjova D., Ecological Studies 28. Springer-Verlag, Berlin. 464 pp., (1978)
	45, Brock Th.C.M., Oecologia 80:44-52., (1989)
	60, Koerselman W., Ph.D. Thesis University of Utrecht. 164 pp., (1989)

62, Koerselman W., J. Ecol. 78:428-442., (1990)
68, Malmer N., In: M. Sonesson (ed.), Ecology of a subarctic mire. Ecological Bulletins (Stockholm) 30:63-95., (1980)
76, Gorham E., J. Ecol. 41:345-360., (1953)
81, Tamm C.O., Oikos 5:189-194., (1954)
112, Wassen M.J., Ph.D. Thesis University of Utrecht., (1990)
119, Koerselman W., In: J.T.A. Verhoeven (ed.), Fens and bogs in the Netherlands: pp. 397-432., (1992)
125, Aerts R., Vegetatio 76:63-69., (1988)
167, Mattson S., Kungl. Landbrukshögsk. Ann. 12:186-203. [Ann. Agric. Coll. Sweden], (1944)
168, Kivekäs J., J. Sci. Agric. Soc. Finland 29:41-55., (1957)
279, Gudde L., The Utrecht Plant Ecology News Report 2:46-52. (in Dutch, English abstract), (1985)
303, Malmer N., Aquilo Ser. Bot. 28:57-65., (1990)

Metals:

Description:	278, Leendertse P., Report Free University, Amsterdam. (in Dutch), (1992)
Lab:	145, Rozema J., Vegetatio 62:293-301., (1985)
	204, Cooper A., New Phytol. 90:263-275., (1982)
	229, Otte M.R., Ph.D. Thesis, Free University Amsterdam., (1991)
	288, Scholten M.C.Th., TNO report R94/073., (1994)
Field:	2, Waughman G.J., J. Ecol. 68:1025-1046., (1980)
	68, Malmer N., In: M. Sonesson (ed.), Ecology of a subarctic mire. Ecological Bulletins (Stockholm) 30:63-95., (1980)
	158, Rozema J., Proc. Int. Conf. Heavy metals in the environment, Athens 1985., (1985)
	167, Mattson S., Kungl. Landbrukshögsk. Ann. 12:186-203. [Ann. Agric. Coll. Sweden], (1944)
	168, Kivekäs J., J. Sci. Agric. Soc. Finland 29:41-55., (1957)
	229, Otte M.R., Ph.D. Thesis, Free University Amsterdam., (1991)
	254, Otte M.L., Environ. Pollut. 82:13-22., (1993)
	257, Reboredo F., Sci. Total Environ. 133:111-132., (1993)
	299, Mattson S., Kungl. Landbrukshögsk. Ann. 12:101-118. [Ann. Agric. Coll. Sweden], (1944)
	303, Malmer N., Aquilo Ser. Bot. 28:57-65., (1990)

Organics:

Description:	278, Leendertse P., Report Free University, Amsterdam. (in Dutch), (1992)
Field:	280, Sarvala J., Hydrobiologia 86:41-53., (1982)

4.4 Element cycles through algae

Table 13: The processes extracted from the "Matrix of Information on Wetland Processes" referred to in this section. For each process/category combination the number of relevant european literature records is indicated. The total can be smaller than the sum, due to references addressing more processes/categories.

Process	Description	Lab	Field	Computer
Uptake & Cycling	1	X	X	X
Nitrogen	2	0	1	1
Phosphorus	5	2	0	1
Potassium	0	0	0	0
Metals	0	0	0	0
Organics	0	0	0	0
Total	8	2	1	2

Only 12 literature records regarding "element cycles through algae" have been selected and reviewed. Most of these studies are related to algal growth as function of nutrient fluxes from wetland soils. A special algal bioassay, aimed at assessing the release of bioavailable P from wetland soils, is described in record 88.

Algae:

Uptake and cycling:

Description:	39, Dykyjova D., Ecological Studies 28. Springer-Verlag, Berlin. 464 pp., (1978)

Nitrogen:

Description:	31, Basilier K., Oikos 34:239-242., (1980)
	100, Golterman H.L., Avan. Oceanol. Med. Bull. Inst. Oceanogr. Mon. Spec. 11:75-87., (1992)
	110, Ahlgren I., Ambio 23:367-377., (1994)
	120, Best E.P.H., Developments in Hydrobiology 88. Kluwer Academic Publishers, Dordrecht. - Hydrobiologia 265., (1993)
Field:	9, Forès E., Mar. Ecol. Prog. Ser. 106:283-290., (1994)
Computer:	9, Forès E., Mar. Ecol. Prog. Ser. 106:283-290., (1994)

Phosphorus:

Description:	77, Hosper S.H., The Utrecht Plant Ecology News Report 11:130-146 / Hydrobiologia 200/201:523-533., (1990)
	99, Jansson M., Hydrobiologia 170:177-189., (1988)
	100, Golterman H.L., Avan. Oceanol. Med. Bull. Inst. Oceanogr. Mon. Spec. 11:75-87., (1992)
	120, Best E.P.H., Developments in Hydrobiology 88. Kluwer Academic Publishers, Dordrecht. - Hydrobiologia 265., (1993)
	210, Holtan H., Hydrobiologia 170:19-34., (1988)
Lab:	88, Klapwijk S.P., In: P.G. Sly (ed.), Sediments and water interactions. Springer-Verlag, New York. pp. 391-398., (1986)
	251, Golterman H.L., In: H.L. Golterman (ed.), Interactions between sediments and freshwater. pp. 286-293., (1977)
Computer:	244, Jorgensen S.E., In: H.L. Golterman (ed.), Interactions between sediments and freshwater. pp. 387-389., (1977)

4.5 Effect of vegetation on soil processes

Table 14: The processes extracted from the "Matrix of Information on Wetland Processes" referred to in this section. For each process/category combination the number of relevant european literature records is indicated. The total can be smaller than the sum, due to references addressing more processes/categories.

Process	Description	Lab	Field	Computer
Substrate modification	3	0	1	0
Aeration	3	7	3	1
Substance excretion	2	0	2	0
detritus production	1	0	0	0
filtering water	16	2	4	1
Total	21	9	10	2

In total 38 literature records regarding "effect of vegetation on soil processes" have been selected and reviewed. A number of papers are dealing with the aeration of soils due to radial oxygen loss (ROL) from plant roots (reviewed in records 200 and 201). The effect of ROL is also coupled with the reduced uptake of iron and manganese (record 145) or metals (record 229). In record 45 a method is presented to characterize the pumping of N and P from soils by Nymphoid waterweeds. A number of studies is dealing with detritus dynamics related to the litter fall and decomposition of dead plant material. The definitions of detritus are reviewed in record 264, while record 275 presents methods to determine the origin, composition and quantity of detritus in field samples. The dynamics of detritus in wetlands is reviewed in record 306, methods for field estimates are given in record 186. The records dealing with vegetation as helophyte filter of waste water are already synthesized in paragraph 4.3.

Emergent vegetation:

Rooting:

Substrate mod.:

Description:	35, Szczepanski A.J., Pol. Ecol. Stud. 4:45-94., (1978)
	84, Winter M., The Utrecht Plant Ecology News Report 4:123-140., (1985)
	226, P.E.J. Laan, Ph.D. Thesis, University of Nijmegen., (1990)
Field:	32, Brock Th.C.M., Aquat. Bot. 17:189-214., (1983)

Aeration:

Description:	117, Oorschot M.M.P. van, The Utrecht Plant Ecology News Report 11:64-85. (in Dutch, English abstract), (1990)
	200, Drew M.C., Plant Soil 75:179-199., (1983)
	201, Armstrong W., In: J.R. Etherington (ed.), Environmental plant ecology. 2nd ed. pp. 290-330., (1982)
Lab:	145, Rozema J., Vegetatio 62:293-301., (1985)
	222, Silvola J., Suo 43:259-262., (1992)
	226, P.E.J. Laan, Ph.D. Thesis, University of Nijmegen., (1990)
	227, Diggelen J. van, Ph.D. Thesis, Free University Amsterdam., (1988)
	229, Otte M.R., Ph.D. Thesis, Free University Amsterdam., (1991)
	238, Armstrong J., New Phytol. 110:383-389., (1988)
	240, Iremonger S.F., New Phytol. 109:491-497., (1988)
Field:	30, Andersen F.O., Holarctic Ecol. 4:66-72., (1981)
	222, Silvola J., Suo 43:259-262., (1992)
	229, Otte M.R., Ph.D. Thesis, Free University Amsterdam., (1991)
Computer:	238, Armstrong J., New Phytol. 110:383-389., (1988)

Substance excretion:

Description:	72, Pieczynska E., Hydrobiologia 251:49-58., (1993)
	86, Haycock N.E., J. Environ. Qual. 22:273-278., (1993)
Field:	233, Wainwright M., Plant Soil 59:357-363., (1979)
	282, Clymo R.S., J. Ecol. 53:747-757., (1965)

Detritus production:

Description:	35, Szczepanski A.J., Pol. Ecol. Stud. 4:45-94., (1978)

Filtering water:

Description:	39, Dykyjova D., Ecological Studies 28. Springer-Verlag, Berlin. 464 pp., (1978)
	84, Winter M., The Utrecht Plant Ecology News Report 4:123-140., (1985)
Lab:	86, Haycock N.E., J. Environ. Qual. 22:273-278., (1993)
	100, Golterman H.L., Avan. Oceanol. Med. Bull. Inst. Oceanogr. Mon. Spec. 11:75-87., (1992)
	106, Vought L.B.M., Ambio 23:342-348., (1994)
	117, Oorschot M.M.P. van, The Utrecht Plant Ecology News Report 11:64-85. (in Dutch, English abstract), (1990)
	266, Rijs G.B.J., The Utrecht Plant Ecology News Report 11:147-166. (in Dutch, English summary), (1990)
	267, Maeseneer J. de, The Utrecht Plant Ecology News Report 4:141-148. (in Dutch, English Abstract), (1985)
	268, Butijn G.D., The Utrecht Plant Ecology News Report 4:64-90. (in Dutch, English Abstract), (1985)
	269, Greiner R.W., The Utrecht Plant Ecology News Report 4:39-63. (in Dutch, English Abstract), (1985)
	270, Duel H., The Utrecht Plant Ecology News Report 11:188-202. (in Dutch, English summary), (1990)
	271, Meuleman A.F.M., The Utrecht Plant Ecology News Report 11:167-187. (in Dutch, English summary), (1990)
	272, Fiselier J.L., The Utrecht Plant Ecology News Report 11:225-246. (in Dutch, English summary), (1990)
	273, Kappe L.J., The Utrecht Plant Ecology News Report 11:204-224. (in Dutch, English summary), (1990)
	278, Leendertse P., Report Free University, Amsterdam. (in Dutch), (1992)
	306, Denny P., Arch. Hydrobiol. Beih. Ergebn. Limnol. 27:1-25., (1987)
	169, Koncalova H., Wetl. Ecol. Manage. 2:199-211., (1993)
	276, Karman C.C., Report Free University, Amsterdam. (in Dutch), (1992)
Field:	12, Knauer N., Z. Kulturtechn. Landentw. 30:365-376. (in German, English abstract), (1989)
	24, Klötzli F., Giorn. Bot. Ital. 121:101-120. (in French, English abstract), (1987)
	48, Heckman C.W., Aquat. Bot. 25:139-151., (1986)
	107, Fleischer S., Ambio 23:349-357., (1994)
Computer:	311, Jorgensen S.E., In: W.J. Mitsch et al. (eds.), Wetland modelling. pp. 133-151., (1988)

4.6 Effect of algae on soil processes

Table 15: The processes extracted from the "Matrix of Information on Wetland Processes" referred to in this section. For each process/category combination the number of relevant european literature records is indicated. The total can be smaller than the sum, due to references addressing more processes/categories.

Process	Description	Lab	Field	Computer
Substrate modification	0	1	2	0
Aeration	0	0	0	1
Substance excretion	2	0	0	1
Detritus production	0	0	0	0
Filtering water	2	0	2	0
Total	3	1	3	1

Only 7 literature records regarding "effect of algae on soil processes" have been selected and reviewed. There are no substantial effects described, other than organic matter loading due to sedimentation of algal debris and subsequent reduced conditions, anoxia and sulphide production.

Algae:

Substrate mod.:

Lab:	289, Scholten M.C.Th., TNO report R94/049., (1994)
Field:	29, Verhoeven J.T.A., Oecologia 60:25-33., (1983)
	289, Scholten M.C.Th., TNO report R94/049., (1994)

Aeration:

Computer:	91, Eck G.Th.M. van, In: P.G. Sly (ed.), Sediments and water interactions. Springer-Verlag, New York. pp. 189-301., (1986)

Substance excretion:

Description:	7, Golterman H.L., Arch. Hydrobiol. Beih. Ergebn. Limnol. 30:1-4., (1988)
	79, Lijklema L., The Utrecht Plant Ecology News Report 11:44-51., (1990)
Computer:	91, Eck G.Th.M. van, In: P.G. Sly (ed.), Sediments and water interactions. Springer-Verlag, New York. pp. 189-301., (1986)

Filtering water:

Description:	79, Lijklema L., The Utrecht Plant Ecology News Report 11:44-51., (1990)
	80, Verhoeven J.T.A., The Utrecht Plant Ecology News Report 11:5-21. (in Dutch, English summary), (1990)
Field:	29, Verhoeven J.T.A., Oecologia 60:25-33., (1983)
	71, Cristofor S., Hydrobiologia 251:143-148., (1993)

4.7 Effect of wetland fauna on soil processes

Table 16: The processes extracted from the "Matrix of Information on Wetland Processes" referred to in this section. For each process/category combination the number of relevant european literature records is indicated. The total can be smaller than the sum, due to references addressing more processes/categories.

Process	Description	Lab	Field	Computer
Bioturbation	3	X	X	X
Sediment dwellers	1	4	1	0
Surface dwellers	1	4	1	0
Total	4	7	2	0

In total 13 literature records regarding "effect of wetland fauna on soil processes" have been selected and reviewed. Most of the studies deal with marine benthos and their effect upon N, P and toxicant fluxes from the sediment due to bioturbation. Other studies are related to the impact of fauna on organic matter decomposition (see also paragraph 3.4).

Wetland fauna:

Bioturbation:

Description:	19, Heal O.W., In: O.W. Heal & D.F. Perkins (eds.), Production ecology of British moors and montane grasslands. pp. 136-159., (1978)
	39, Dykyjova D., Ecological Studies 28. Springer-Verlag, Berlin. 464 pp., (1978)
	77, Hosper S.H., The Utrecht Plant Ecology News Report 11:130-146 / Hydrobiologia 200/201:523-533., (1990)

Sediment dwellers:

Description:	98, Andersson G., Hydrobiologia 170:267-284., (1988)
Lab:	95, Marquenie J.M., TNO report R85/075., (1985)
	101, Kristensen E., J. Exp. Mar. Biol. Ecol. 75:171-190., (1984)
	104, Pelegri S.P., Mar. Ecol. Prog. Ser. 105:285-290., (1994)
	192, Regnault M., Cah. Biol. Mar. 29:427-444., (1988)
Field:	235, Alkemade R., Mar. Ecol. Prog. Ser. 99:293-300., (1993)

Surface dwellers:

Description:	98, Andersson G., Hydrobiologia 170:267-284., (1988)
Lab:	36, Marquenie J.M., TNO report V14, Den Helder., (1985)
	192, Regnault M., Cah. Biol. Mar. 29:427-444., (1988)
	213, Ostergaard Andersen F., Limnol. Oceanogr. 37:1392-1403., (1992)
	316, Pelegri S.P., Mar. Biol. 121:253-258., (1994)
Field:	283, Menéndez M., Arch. Hydrobiol. 117:39-48., (1989)

4.8 Effect of wetland conditions on flora and fauna

Table 17: The processes referred to in this section are not included in the original "Matrix of Information on Wetland Processes", and are strongly related to specific European types of wetland research. For each process/category combination the number of relevant european literature records is indicated. The total can be smaller than the sum, due to references addressing more processes/categories.

Process	Description	Lab	Field	Computer
Tolerances	2	x	x	x
Salt marsh flora	3	24	6	0
Reed swamp flora	4	3	6	1
Fen/bog flora	9	5	31	2
Floodplain flora	1	2	8	1
Wetland fauna	2	0	1	0
Total	16	31	46	2

In total 92 literature records regarding "effect of wetland conditions on flora and fauna" have been selected and reviewed. A large part of these records categorized under "lab" are related to autecological studies with wetland plant species under experimental conditions, in order to establish the ecological amplitudo with respect to various soil conditions (e.g. anoxia, low redox, sulphide, salinity, alkalinity, nutrient availability, waterlogging, submersion). Most studies categorized under "field" are correlative studies between actual soil conditions and presence or vitality of plant species, and in one case (record 148) faunal species.

Tolerances:

Description:	200, Drew M.C., Plant Soil 75:179-199., (1983)
	201, Armstrong W., In: J.R. Etherington (ed.), Environmental plant ecology. 2nd ed. pp. 290-330., (1982)

Salt marsh flora:

Description:	102, Hemminga M.A., Mar. Ecol. Prog. Ser. 71:85-96., (1991)
	120, Best E.P.H., Developments in Hydrobiology 88. Kluwer Academic Publishers, Dordrecht. - Hydrobiologia 265., (1993)
	224, Adam P., Cambridge Studies in Ecology. Cambridge University Press, Cambridge. 461 pp., (1990)
Lab:	26, Pearson J., J. Exp. Bot. 39:363-374., (1988)
	118, Jones H.E., J. Ecol. 58:487-496., (1970)
	128, Pehrsson O., Vegetatio 74:113-124., (1988)
	131, Ahmad I., New Phytol. 79:605-612., (1977)
	135, Bakker J.P., New Phytol. 101:291-308., (1985)
	138, Ignaciuk R., New Phytol. 84:581-591., (1980)
	141, Weihe K. von, Helgoländer wiss. Meeresunters. 32:239-254., (1979)
	143, Rozema J., J. Ecol. 65:213-222., (1977)
	144, Rozema J., Acta Bot. Neerl. 24:407-416., (1975)
	145, Rozema J., Vegetatio 62:293-301., (1985)
	146, Rozema J., Oecologia 34:329-341., (1978)
	153, Woodell S.R.J., Vegetatio 61:223-229., (1985)
	154, Tiku B.L., Plant Soil 35:421-431., (1971)
	157, Rozema J., Vegetatio 62:499-522., (1985)
	159, Rozema J., New Phytol. 89:201-217., (1981)
	163, Davies M.S., New Phytol. 94:573-583., (1983)
	164, Jensen A., Vegetatio 61:231-240., (1985)
	172, Jefferies R.L., J. Ecol. 65:847-865., (1977)
	177, Stewart G.R., In: R.I. Jefferies & A.J. Davy (eds.), Ecological processes in the coastal environments. pp. 211-227, (1977)
	202, Weihe K. von, Beitr. Biol. Pflanzen 54:145-163., (1978)
	204, Cooper A., New Phytol. 90:263-275., (1982)
	205, Flowers T.J., Plant Soil 89:41-56., (1985)
	227, Diggelen J. van, Ph.D. Thesis, Free University Amsterdam., (1988)
	230, Rozema J., Ph.D. Thesis, Free University Amsterdam., (1978)
Field:	127, Jerling L., Vegetatio 74:161-170., (1988)
	130, Ahmad I., New Phytol. 76:361-366., (1976)
	138, Ignaciuk R., New Phytol. 84:581-591., (1980)
	171, Jefferies R.L., J. Ecol. 65:867-882., (1977)
	230, Rozema J., Ph.D. Thesis, Free University Amsterdam., (1978)
	277, Leendertse P.C., Report Free University, Amsterdam. (in Dutch), (1992)

Reed swamp flora:

Reed swamp flora:

Description:	35, Szczepanski A.J., Pol. Ecol. Stud. 4:45-94., (1978)
	54, Verhoeven J.T.A. (ed.), Geobotany 18, Kluwer Academic Publishers, Dordrecht., (1992)
	120, Best E.P.H., Developments in Hydrobiology 88. Kluwer Academic Publishers, Dordrecht. - Hydrobiologia 265., (1993)
	271, Meuleman A.F.M., The Utrecht Plant Ecology News Report 11:167-187. (in Dutch, English summary), (1990)
Lab:	28, Veerkamp M.T., Physiol. Plant. 50:237-240., (1980)
	96, Crawford R.M.M., Flora 182:189-201., (1989)
	139, Robertson K.P., Plant Cell Environ. 10:45-52., (1987)
Field:	46, Atwell B.J., Physiol. Plant. 49:487-494., (1980)
	74, Kühl H., Hydrobiologia 251:1-12., (1993)
	286, Mountford J.O., J. Environ. Manage. 38:275-288., (1993)
	293, Beltman B., In: J.T.A. Verhoeven et al. (eds.), Vegetation structure in relation to carbon and nutrient economy. pp. 121-135., (1988)
	300, Vermeer H.J.G., The Utrecht Plant Ecology News Report 2:8-17. (in Dutch, English abstract), (1985)
	317, Zonneveld I.S., Thesis University of Wageningen, Stiboka Bodemkundige studies No. 4., (1960)
Computer:	129, Braak C.J.F. ter, Vegetatio 69:79-87., (1987)

Fen / bog flora:

Description:	37, Malmer N., Bot. Not. 108:46-80., (1955)
	44, Malmer N., Can. J. Bot. 64:375-383., (1986)
	54, Verhoeven J.T.A. (ed.), Geobotany 18, Kluwer Academic Publishers, Dordrecht., (1992)
	120, Best E.P.H., Developments in Hydrobiology 88. Kluwer Academic Publishers, Dordrecht. - Hydrobiologia 265., (1993)
	123, Sjörs H., Oikos 2:241-258., (1950)
	252, Jauhiainen J., Suo 43:211-215., (1992)
	287, Janiesch P., In: J. Rozema & J.A.C. Verkleij (eds.), Ecological responses to environmental stresses. pp. 50-60., (1991)
	291, Malmer N., Aquilo Ser. Bot. 21:9-17., (1985)
	301, Pietsch W., In: Proceedings of the 5th international peat congress, Poznan, Poland. pp. 62-72., (1976)
Lab:	14, Loach K., J. Ecol. 56:117-127., (1968)
	28, Veerkamp M.T., Physiol. Plant. 50:237-240., (1980)
	96, Crawford R.M.M., Flora 182:189-201., (1989)
	199, Rydin H., Proc. R. Soc. Lond. B 237:63-84., (1989)
	240, Iremonger S.F., New Phytol. 109:491-497., (1988)
Field:	2, Waughman G.J., J. Ecol. 68:1025-1046., (1980)
	3, Brock T.C.M., In: J.T.A. Verhoeven et al. (eds.), Vegetation structure in relation to carbon and nutrient economy. pp. 45-60., (1988)
	14, Loach K., J. Ecol. 56:117-127., (1968)
	46, Atwell B.J., Physiol. Plant. 49:487-494., (1980)
	51, Persson A., Opera Botanica 6(3). 100 pp., (1962)

	55, Malmer N., Opera Botanica 7(1). 322 pp., (1962)
	56, Malmer N., Opera Botanica 7(2). 67 pp., (1962)
	57, Saebo S., Meld. Norges Landbrukshögsk. 49. 37 pp., (1970)
	58, Saebo S., Meld. Norges Landbrukshögsk. 47. 67 pp., (1968)
	60, Koerselman W., Ph.D. Thesis University of Utrecht. 164 pp., (1989)
	61, Koerselman W., Wetl. Ecol. Manage. 1:73-84., (1990)
	66, Sonesson M., In: M. Sonesson (ed.), Ecology of a subarctic mire. Ecological Bulletins (Stockholm) 30:191-207., (1980)
	67, Kvillner E., In: M. Sonesson (ed.), Ecology of a subarctic mire. Ecological Bulletins (Stockholm) 30:97-111., (1980)
	75, Gorham E., J. Ecol. 41:153-156., (1953)
	81, Tamm C.O., Oikos 5:189-194., (1954)
	112, Wassen M.J., Ph.D. Thesis University of Utrecht., (1990)
	119, Koerselman W., In: J.T.A. Verhoeven (ed.), Fens and bogs in the Netherlands: pp. 397-432., (1992)
	125, Aerts R., Vegetatio 76:63-69., (1988)
	160, Gorham E., J. Ecol. 44:129-141., (1956)
	161, Gorham E., Oikos 2:217-240., (1950)
	167, Mattson S., Kungl. Landbrukshögsk. Ann. 12:186-203. [Ann. Agric. Coll. Sweden], (1944)
	243, Arts G.H.P., Can. J. Bot. 68:2127-2134., (1990)
	256, Reinikainen A., Ann. Bot. Fennici 21:79-101., (1984)
	285, Grootjans A.P., Acta Oecol. Oecol. Plant. 6:403-417., (1985)
	286, Mountford J.O., J. Environ. Manage. 38:275-288., (1993)
	290, Strien A.J. van, J. Appl. Ecol. 26:989-1004., (1989)
	293, Beltman B., In: J.T.A. Verhoeven et al. (eds.), Vegetation structure in relation to carbon and nutrient economy. pp. 121-135., (1988)
	299, Mattson S., Kungl. Landbrukshögsk. Ann. 12:101-118. [Ann. Agric. Coll. Sweden], (1944)
	300, Vermeer H.J.G., The Utrecht Plant Ecology News Report 2:8-17. (in Dutch, English abstract), (1985)
	303, Malmer N., Aquilo Ser. Bot. 28:57-65., (1990)
	313, Jónsdóttir I.S., Sci. Total Environ. 160/161:677-685., (1995)
Computer:	129, Braak C.J.F. ter, Vegetatio 69:79-87., (1987)
	310, Logofet D.O., In: W.J. Mitsch et al. (eds.), Wetland modelling. pp. 55-66., (1988)

Floodplain flora:

Description:	187, Junk W.J., In: B.C. Patten & S.E. Jorgensen (eds.), Wetlands and shallow water bodies. pp. 491-524., (1990)
Lab:	28, Veerkamp M.T., Physiol. Plant. 50:237-240., (1980)
	226, P.E.J. Laan, Ph.D. Thesis, University of Nijmegen., (1990)
Field:	46, Atwell B.J., Physiol. Plant. 49:487-494., (1980)
	53, Sonesson M. (ed.), Swedish Natural Science Research Council, Ecological Bulletins 30. 313 pp., (1980)
	155, Schat H., Vegetatio 61:189-195., (1985)
	156, Schat H., Acta Oecol. Oecol. Plant. 7:221-231., (1986)

	226, P.E.J. Laan, Ph.D. Thesis, University of Nijmegen., (1990) 242, Arts G.H.P., Freshwater Biol. 24:287-294., (1990) 265, Bakker J.P., Acta Bot. Neerl. 36:39-58., (1987) 317, Zonneveld I.S., Thesis University of Wageningen, Stiboka Bodemkundige studies No. 4., (1960)
Computer:	129, Braak C.J.F. ter, Vegetatio 69:79-87., (1987)

Wetland fauna:

Description:	187, Junk W.J., In: B.C. Patten & S.E. Jorgensen (eds.), Wetlands and shallow water bodies. pp. 491-524., (1990) 224, Adam P., Cambridge Studies in Ecology. Cambridge University Press, Cambridge. 461 pp., (1990)
Field:	148, Castella E., Wetl. Ecol. Manage. 3:17-36., (1994)

5. WETLAND ECOSYSTEM DEVELOPMENT

5.1 General introduction

Wetland ecotopes are generally classified according to the prevailing vegetation type, which is the result of allogenic zonation according to the tolerances of individual species to the soil conditions experienced, or the result of autogenic succession resulting in a transition series from opportunistic and generalistic colonists towards conservative and specialized competitors. In both situations, competition amongst wetland plant species strongly determines the resultant vegetation structure.

Incidental climatic disturbances (i.e. periods of frost, drought and heat) can interfere with the (plant competition based) wetland ecosystem development (zonation or succession).

Wetland vegetation characteristics can be used to evaluate the wetland development against nature conservancy objectives.

5.2 Succession and zonation

Table 18: The processes extracted from the "Matrix of Information on Wetland Processes" referred to in this section. For each process/category combination the number of relevant european literature records is indicated. The total can be smaller than the sum, due to references addressing more processes/categories.

Process	Description	Lab	Field	Computer
Vegetative succession	17	5	21	1

In total 42 literature records regarding "succession and zonation" have been selected and reviewed, mainly botanic descriptive or field studies.

Studies of interest are those related to early succession, measured in experimental outdoor mesocosm studies (e.g. records 214, 288) or in real field studies (e.g. records 133, 141, 152), and those related to species composition along an environmental gradient explained on the basis of shifts in competitive relations (e.g. records 44, 142). Many studies describe the changes in plant communities in hydroseries. A nice method to characterize the regular wetness status of soils on the basis of phytosociological data (presence of certain indicator plant species) has been developed by Ellenberg (original paper is record 215, with operational application methods given in records 129, 265 and 286). A "Feuchtzahl" (Moisture grade) between 1 and 12 indicates the type of wetness of soils. Wetlands soils are characterized by a "Feuchtzahl" between 8 and 11. Record 149 is a recent paper on biodiversity of wetlands with reference to the UNCED conference in Rio de Janeiro.

Vegetative succession:

Description:

35, Szczepanski A.J., Pol. Ecol. Stud. 4:45-94., (1978)

39, Dykyjova D., Ecological Studies 28. Springer-Verlag, Berlin. 464 pp., (1978)

44, Malmer N., Can. J. Bot. 64:375-383., (1986)

54, Verhoeven J.T.A. (ed.), Geobotany 18, Kluwer Academic Publishers, Dordrecht., (1992)

120, Best E.P.H., Developments in Hydrobiology 88. Kluwer Academic Publishers, Dordrecht. - Hydrobiologia 265., (1993)

121, Moore P. (ed.), Academic Press, London., (1984)

124, Dijk H.W.J. van, Acta Bot. Neerl. 34:301-319., (1985)

129, Braak C.J.F. ter, Vegetatio 69:79-87., (1987)

132, Bakker J.P., Vegetatio 44:81-100., (1981)

142, Scholten M., In: A.H.L. Huiskes et al.(eds.), Vegetation between land and sea. pp. 270-281., (1987)

149, Denny P., Wetl. Ecol. Manage. 3:55-61., (1994)

186, Damman A.W.H., Suo 43:137-145., (1992)

215, Ellenberg H., Scripta Geobotanica 9. 97 pp. (in German, English abstract), (1974)

224, Adam P., Cambridge Studies in Ecology. Cambridge University Press, Cambridge. 461 pp., (1990)

226, P.E.J. Laan, Ph.D. Thesis, University of Nijmegen., (1990)

259, Markstein B., Garten + Landschaft 1/80:30-36. (in German and English), (1980)

306, Denny P., Arch. Hydrobiol. Beih. Ergebn. Limnol. 27:1-25., (1987)

Lab:

134, Beeftink A., Vegetatio 61:33-44., (1985)

141, Weihe K. von, Helgoländer wiss. Meeresunters. 32:239-254., (1979)

152, Zahran M.A., J. Coast. Res. 3:359-368., (1987)

214, Stockey A., J. Appl. Ecol. 31:543-559., (1994)

288, Scholten M.C.Th., TNO report R94/073., (1994)

Field:

53, Sonesson M. (ed.), Swedish Natural Science Research Council, Ecological Bulletins 30. 313 pp., (1980)

55, Malmer N., Opera Botanica 7(1). 322 pp., (1962)

56, Malmer N., Opera Botanica 7(2). 67 pp., (1962)

60, Koerselman W., Ph.D. Thesis University of Utrecht. 164 pp., (1989)

76, Gorham E., J. Ecol. 41:345-360., (1953)

119, Koerselman W., In: J.T.A. Verhoeven (ed.), Fens and bogs in the Netherlands: pp. 397 432., (1992)

133, Brereton A.J., J. Ecol. 59:321-338., (1971)

134, Beeftink A., Vegetatio 61:33-44., (1985)

135, Bakker J.P., New Phytol. 101:291-308., (1985)

152, Zahran M.A., J. Coast. Res. 3:359-368., (1987)

165, Groenedijk A.M., Vegetatio 62:415-424., (1985)

166, Groenedijk A.M., Vegetatio 57:143-152., (1984)

203, Weihe K. von, ??., ()

236, Grosse-Brauckmann G., Flora 163:179-229. (in German, English abstract), (1974)

239, Grosse-Brauckmann G., Flora 165:415-455. (in German, English abstract), (1976)

	242, Arts G.H.P., Freshwater Biol. 24:287-294., (1990)
	265, Bakker J.P., Acta Bot. Neerl. 36:39-58., (1987)
	277, Leendertse P.C., Report Free University, Amsterdam. (in Dutch), (1992)
	290, Strien A.J. van, J. Appl. Ecol. 26:989-1004., (1989)
	304, Grootjans A.P., Acta Oecol. Oecol. Plant. 7:3-14., (1985)
	305, Vermeer J.G., Acta Oecol. Oecol. Plant. 7:31-41., (1986)
Computer:	176, Long S.P., In: R.I. Jefferies & A.J. Davy (eds.), Ecological processes in the coastal environments. pp. 333-352., (1977)

5.3 Climatic disturbances

Table 19: The processes extracted from the "Matrix of Information on Wetland Processes" referred to in this section. For each process/category combination the number of relevant european literature records is indicated. The total can be smaller than the sum, due to references addressing more processes/categories.

Process	Description	Lab	Field	Computer
Freezing/ice effects	0	3	4	0
Heat effects	1	1	2	0
Drought effects	1	2	7	0
Total	2	4	11	0

In total 16 literature records regarding "climatic disturbances" have been selected and reviewed. Freezing effects are mainly studied in subartic mires and tundras in Scandiniavia. There are no European studies known on real heat effects. Some incubation studies under moderately high temperatures under lab conditions are categorized under this process. Concerning the situation regarding drought effects, only lowering of groundwater level or drainage has been studied in Europe (e.g. records 206, 285, 304). No records have been found related to drought effects accompanying seasonal periodicity in (semi-)arid regions.

Freezing / Ice effects

Lab:	27, Saebo S., Meld. Norges Landbrukshögsk. 48:1-10., (1969)
	58, Saebo S., Meld. Norges Landbrukshögsk. 47. 67 pp., (1968)
	85, Koerselman W., Biogeochemistry 20:63-81., (1993)
Field:	53, Sonesson M. (ed.), Swedish Natural Science Research Council, Ecological Bulletins 30. 313 pp., (1980)
	67, Kvillner E., In: M. Sonesson (ed.), Ecology of a subarctic mire. Ecological Bulletins (Stockholm) 30:97-111., (1980)
	94, Ryden B.E., In: M. Sonesson (ed.), Ecology of a subarctic mire. Ecological Bulletins (Stockholm) 30:251-281., (1980)
	248, Abdollahi H., Microbial Ecol. 5:73-79., (1979)

Heat effects:

Description:	19, Heal O.W., In: O.W. Heal & D.F. Perkins (eds.), Production ecology of British moors and montane grasslands. pp. 136-159., (1978)
Lab:	85, Koerselman W., Biogeochemistry 20:63-81., (1993)
Field:	67, Kvillner E., In: M. Sonesson (ed.), Ecology of a subarctic mire. Ecological Bulletins (Stockholm) 30:97-111., (1980)
	248, Abdollahi H., Microbial Ecol. 5:73-79., (1979)

Drought effects:

Description:	114, Kemmers R.H., The Utrecht Plant Ecology News Report 10:7-22. (in Dutch, English Abstract), (1990)
Lab:	58, Saebo S., Meld. Norges Landbrukshögsk. 47. 67 pp., (1968)
	230, Rozema J., Ph.D. Thesis, Free University Amsterdam., (1978)
Field:	29, Verhoeven J.T.A., Oecologia 60:25-33., (1983)
	194, Sakovets V., Suo 43:249-252., (1992)
	206, Martikainen P.J., Suo 43:237-240., (1992)
	230, Rozema J., Ph.D. Thesis, Free University Amsterdam., (1978)
	285, Grootjans A.P., Acta Oecol. Oecol. Plant. 6:403-417., (1985)
	302, Freeman C., Soil. Biol. Biochem. 26:1439-1442., (1994)
	304, Grootjans A.P., Acta Oecol. Oecol. Plant. 7:3-14., (1985)

5.4 Habitat management

Table 20: The processes referred to in this section are not included in the original "Matrix of Information on Wetland Processes", and are strongly related to specific European types of wetland research.

Process	Description	Lab	Field	Computer
Habitat management	4	x	x	x

Only 4 literature records regarding "effect of wetland conditions on flora and fauna" have been selected and reviewed. All these studies are descriptive and are only related to the management and restoration of wetland areas severely disturbed by human activities. Studies related to wetland soil and vegetation processes, but which are useful for wetland management, are not classified under this topic "habitat management".

Management:

Description:

77, Hosper S.H., The Utrecht Plant Ecology News Report 11:130-146 / Hydrobiologia 200/201:523-533., (1990)

182, Straskraba M., In: B.C. Patten & S.E. Jorgensen (eds.), Wetlands and shallow water bodies. pp. 425-444., (1990)

188, Toorn J. van der, In: B.C. Patten & S.E. Jorgensen (eds.), Wetlands and shallow water bodies. pp. 445-465., (1990)

312, Straskraba M., In: W.J. Mitsch et al. (eds.), Wetland modelling. pp. 153-175., (1988)

APPENDIX: LITERATURE RECORDS

1 (1990) Verhoeven J.T.A., E. Maltby & M.B. Schmitz

Nitrogen and phosphorus mineralization in fens and bogs.
J. Ecol. 78:713-726.

Ten Dutch mires were compared with respect to N and P content and mineralization and cellulose decomposition rate. The size of the inorganic N pool was not related to depth, mire type or the presence of a Sphagnum cover. The labile inorganic P pool was larger in Sphagnum dominated bogs than in phanerogam dominated fens. Cellulose decomposition rate was faster in phanorogam-dominated fens N and P mineralization was faster in bogs with Sphagnum cover than in phanerogam dominated fens, and faster at 10 cm than at 25 cm.

2 (1980) Waughman G.J.

Chemical aspects of the ecology of some south German peatlands.
J. Ecol. 68:1025-1046.

The concentration of inorganic constituents of mire vegetation and underlying peat at fifty sites in southern Germany is related to the fen-bog vegetation gradient

3 (1988) Brock T.C.M., M.A.A. de la Haye & W. Tenner

History, population structure and phytomass production of Betula pubescens in a wetland forest.
In: J.T.A. Verhoeven, G.W. Heil & M.J.A. Werger (eds.), Vegetation structure in relation to carbon and nutrient economy. SPB Academic Publishing, The Hague. pp. 45-60.

Population structure and above ground phytomass of a Birch population were related to water-table management. Drainage of a site improved conditions for establishment between 1943 and 1956. Between 1956 and 1971 stocking density was so high that establishment was hampered due to self-shading. Damming of surrounding ditah in 1971 led to a high water table again, causing an increased Sphagnum cover, which offers only limited possibilities to birch seedlings to survive.

4 (1988) Buth G.J.C. & L.A.C.J. Voesenek

Respiration of standing and fallen plant litter in a Dutch salt marsh.
In: J.T.A. Verhoeven, G.W. Heil & M.J.A. Werger (eds.), Vegetation structure in relation to carbon and nutrient economy. SPB Academic Publishing, The Hague. pp. 51-60.

A study of decomposition and microbial respiration of saltmarsh standing and fallen litter of Triglochin, Limonium and Spartina in an estuarine saltmarsh.

5 (1990) El-Habr H. & H.L. Golterman

In vitro and in situ studies on nitrate disappearance in water-sediment systems of the Camargue
(southern France).
Hydrobiologia 192:223-232.

Denitrification rates of added nitrate and measured in vitro and in situ experiments

6 (1990) Groot C.J. de & H.L. Golterman

Sequential fractionation of sediment phosphate.
Hydrobiologia 192:143-148.

Comparison of methods to extract different P-fractions from aquatic sediments.

7 (1988) Golterman H.L.

Reflections on fractionation and bioavailability of sediment bound phosphate.
Arch. Hydrobiol. Beih. Ergebn. Limnol. 30:1-4.

Opening address of a workshop on the role of sediment in the P-cycle in lakes. An overview is given of what is still not known about phosphorous release from sediments.

8 (1988) Verhoeven J.T.A., A.M. Kooijman & G. van Wirdum

Mineralization of N and P along a trophic gradient in a freshwater mire.
Biogeochemistry 6:31-43.

Release of inorganic nitrogen and phosphorous from the soil of a peatland (fen) was measured by means of an in situ incubation technique, along a gradient in plant productivity and water chemistry.

9 (1994) Forès E., R.R. Christian, F.A. Comin & M. Menendez

Network analysis on nitrogen cycling in a coastal lagoon.
Mar. Ecol. Prog. Ser. 106:283-290.

Network analysis was applied to nitrogen cycling data from 6 ecosystem components in Tancada Laggon (NE Spain) to ascertain the relative importance of internal recycling versus external exchanges, the main biogeochemical processes, and the fate of nitrogen imported to the lagoon.

10 (1973) Gies T. & W. Lötschert

Untersuchungen über den Kationengehalt im Hochmoor. II. Jahreszeitliche Veränderungen und Einfluss der Sphagnen-Vegetation. [Investigations on the cation-content in a bog. II. Seasonal changes and influence of the Sphagnum vegetation.]
Flora 162:244-268. (in German, English abstract)

Ca, Mg, Na and K concentrations in water and living Sphagnum were measured, as well as the pH. No seasonal effect, were observed, but cation concentrations may fluctuate with rainfall.

11 (1993) Haycock N.E. & T.P. Burt

Role of floodplain sediments in reducing the nitrate concentration of subsurface run-off: A case study in the Cotswolds, UK.
Hydrol. Process. 7:287-295.

Discharge of groundwater from a limestone aquifer through floodplain sediments is associated with a large decrease in the nitrate concentration of the water. Results are presented to show that only a small amount of this reduction is caused by dilution of groundwater by water already present within the floodplain sediments; most of the effect is an active reduction process, most probably biological denitrification. The nitrate reduction process appears to operate independently of surface vegetation type and tends to be focused in specific regions of floodplain where sediments are anaerobic and carbon-rich. The results suggest that active denitrification can operate throughout the winter, when nitrate concentrations in groundwater are at their highest and the process remains effective during periods of maximum run-off. The results show that undrained floodplains can be used as buffer zones to protect waters from groundwater polluted with agricultural derived nitrate.

12 (1989) Knauer N. & Ü Mander

Untersuchungen über die Filterwirkung verschiedener Saumbiotope an Gewässern in Schleswig-Holstein. 1. Mitteilung: Filterung von Stickstoff und Phosphor. [Studies on the filtration effect of differently vegetated buffer stripes along inland water in Schleswig-Holstein. 1. Information: Filtration of nitrogen and phosphorus.]
Z. Kulturtechn. Landentw. 30:365-376. (in German, English abstract)

The filtration effect of differentially vegetated natural and/or seminatual biotopes along ditchesand lakes below intensively managed agricultural fields was studied in four test areas in East Holstein. The best filters for N and P are alder woods and natural grasslands, with best results in the vegetation period. The first 10 meters of the buffer ships are the most important, removing 100% of P and 50% of N.

13 (1960) Koutler-Andersson E.

Geochemistry of a raised bog. III. Correlation between total nitrogen and ash alkalinity in bog-peats.
Kungl. Lantbrukshögsk. Ann. 26:33-40.

The correlation between total nitrogen and excess base in ash was investigated in 12 peat profiles. In all bog profiles a negative correlation was found, but not in the fen profiles.

14 (1968) Loach K.

Relations between soil nutrients and vegetation in wet-heaths. II. Nutrient uptake by the major species in the field and in controlled conditions.
J. Ecol. 56:117-127.

The present paper considers the interaction of soil nutrients and moisture levels as they affect growth and relative abundance (competition) of Molina caerula, Calluna vulgaris and Erica tetralix. In greenhouse experiments the effects of different soil nutrient levels was seperated from their interaction with soil moisture conditions. Dry matter yield and nutrient

uptake of these species growing free from interspecific competition was measured in a field experiment.

15 (1978) Pakarinen P.

Production and nutrient ecology of three Sphagnum species in southern Finnish raised bogs. Ann. Bot. Fennici 15:15-26.

Samples of Sphagnum fuscum (Schrimp.) Klinggr. (from hummocks) and of S. balthicum (Russow) C. Jens. and S. majus (Russow) C. Jens. (from hollows) were analysed for growth characteristics and for the quantities of some macronutrients (N, P, K, Ca, Mg) and ash in ombrotrophic conditions. The annual growth in length and net production per unit area of full moss cover were lower in S. fuscum than in the two hollow species. The hollow Sphagna contained significantly less calcium per unit dry weight than S. fuscum. The relative accumulation of elements in live Sphagnum was studied by calculating the ratio of the nutrient consumption by moss in the atmospheric input (both per unit area), which gave a ranking K>P>N>Mg>Ca. This suggests that the element most actively recycled by the mos layer is potassium. The same ranking was obtained with the ratio of the concentrations of these elements in Sphagnum to those in bog pool water. In vertical profiles all three species had higher concentrations of potassium, nitrogen and phosphorus in the live green portion than in the dead brown moss below.

16 (1977) Pakarinen P. & K. Tolonen

Nutrient contents of Sphagnum mosses in relation to bog water chemistry in northern Finland.
Lindbergia 4:27-33.

Major nutrients (N, P, K, Ca, Mg, Na, Fe) were analysed in 38 Sphagnum and water samples taken mainly from bogs and poor fens. The contents of K, Mg, and Ca in mosses were significantly higher in minerotrophic fens than in ombrotrophic bog sites. The corresponding water analyses did not reveal a significant difference with respect to Ca or K. It was also found that P and K were much more enriched into moss tissue from water than for example Ca or Fe.

17 (1988) Pinay G. & H. Decamps

The role in riparian woods in regulating nitrogen fluxes between the alluvial aquifer and surface water: A conceptual model.
Regul. Rivers Res. Manage. 2:507-516.

Conceptual models are proposed to explain nitrogen fluxes in the soils of riparian zones in relation to the different modalities of water logging and nitrate imputs. Non-submerged, temporarily submerged, and always submerged, sites are considered in both winter and summer. It is shown that capacities for epuration are elevated for nitrate loads from the alluvial aquifer during the lateral transfer of water from agricultural land to the river through the riparian zone. About 30 m of groundwater flow under the riparian wood studied is sufficient to remove all nitrate. Denitrification rates up to 50 mg N2 per m2 per day were observed in the field, but a potential for more denitrification exists. The efficiency of the riparian woods as natural filters regulating nutrient transfers to the river deserves more consideration in river management.

18 (1978) Jones H.E. & A.J.P. Gore

A simulation of production and decay in blanket bog.
In: O.W. Heal & D.F. Perkins (eds.), Production ecology of British moors and montane grasslands. Ecological Studies 27. Springer-Verlag, Berlin. pp. 160-186.

The compatibility of estimates of primary production and rates of decomposition is assessed by combining them in a mathemathical model which examines the effects of variability in production and decay and calculates accumulation of peat for comparison with observed values.

19 (1978) Heal O.W., P.M. Latter & G. Howson

A study of the rates of decomposition of organic matter.
In: O.W. Heal & D.F. Perkins (eds.), Production ecology of British moors and montane grasslands. Ecological Studies 27. Springer-Verlag, Berlin. pp. 136-159.

Description of litter decomposition and related nutrient cycling as influenced by environmental parameters, microbial activity and faunal activity.

20 (1978) Martin N.J. & A.J. Holding

Nutrient availability and other factors limiting microbial activity in the blanket peat.
In: O.W. Heal & D.F. Perkins (eds.), Production ecology of British moors and montane grasslands. Ecological Studies 27. Springer-Verlag, Berlin. pp. 113-135.
Laboratory investigations using a non-cyclic percolation system through a peat-sand mixture provided information about nutrient influence on microbial numbers and the release and immobilization of nutrients. respiration measurements were made on homogenised and unhomogenised peats. Results of these experiments, and the changes produced in the microbial population by nutrient addition in the field, are discussed in relation to other chemical and physical soil characteristics, and to studies in nitrogen fixation.

21 (1978) Collins V.G., B.T. D'Sylva & P.M. Latter

Microbial populations in peat.
In: O.W. Heal & D.F. Perkins (eds.), Production ecology of British moors and montane grasslands. Ecological Studies 27. Springer-Verlag, Berlin. pp. 94-112.

Samples were taken at several sites at Moor House blanket Bog. Subsamples taken at four colour horizons were inoculated into the appropriate bacteriological and mycological media. The potential activity of selected groups in relation to nutrient cycling and the taxonomy of those groups participating in the nitrogen or sulphur cycles, or in the hydrolysis of some natural occurring organic compounds is described.

22 (1981) Sondergaard M.

Kinetics of extracellular release of 14C-labelled organic carbon by submerged macrophytes.
Oikos 36:331-347.

In laboratory experiments with six submerged freshwater macrophytes, the release of extracellular products was low and does not suggest any major contributions to the pool of dissolved organic carbon in freshwater. But as a large fraction of the total extracellular organic carbon was low molecular weight products, a fast heterotrophic turnover of the released compounds in the epiphytic community or in the pelagic zone can be expected.

23 (1985) Kemmers R.H. & P.C. Jansen

Stikstofmineralisatie in onbemeste half-natuurlijke graslanden.
ICW Rapporten (nieuwe serie) 14. 20 pp. (in Dutch)

A method is developed to quantify nitrogen supply to semi-natural vegetations in relation to moisture content, temperature and pH of the soil. With a simulation model nitrogen supply is calculated for several vegetation types as influenced by seasonal changes in moisture content and silt temperature.

24 (1987) Klötzli F.

Régions humides oligotrophes dans notre paysage eutrophe. Augmentations de l'expulsion anthropogène de matières nutritives (N, P). [Oligotrophic wetlands in eutrophicated landscape. Augmentation of the antropogenic output of nutrients (N, P).]
Giorn. Bot. Ital. 121:101-120. (in French, English abstract)

Nutrient gradients are assessed along transects from eutrophic to oligotrophic sites to be able to detect nutrient fluxes and consequently buffer endangered sites

25 (1992) Leonardson L.

Vad är egentligen denitrifikation och hur mäts den? [What is denitrification and how is it measured?]
Vatten 48:221-230. (in Swedish, English abstract)

Review of the denitrification process in wetland sediments and a discussion of analytical techniques used to quantify denitrification.

26 (1988) Pearson J. & D.C. Havill

The effect of hypoxia and sulphide on culture-grown wetland and non-wetland plants. I. Growth and
nutrient uptake.
J. Exp. Bot. 39:363-374.

Comparison of growth and nutrient uptake of two flood-intolerant (Agropyron, Hordeum) and two flood tolerant (Oryza, Aster) plants, when cultured in aerated, un-aerated + sulphide, culture solution.

27 (1969) Saebo S.

On the mechanism behind the effect of freezing and thawing on dissolved phosphorus in *Sphagnum fuscum* peat.
Meld. Norges Landbrukshögsk. 48:1-10.

Freezing and thanning of peat samples induces a release of soluble phosphorus. The mechanism (competition with ammonium ions) is discussed.

28 (1980) Veerkamp M.T., W.J. Corré B.J. Atwell & J.C. Kuiper

Growth rate and phosphate utilization of some *Carex* species from a range of oligotrophic to eutrophic swamp habitats.
Physiol. Plant. 50:237-240.

Five Carex species, differing with respect to nutrient availability in their natural habitat, were cultured with varying phosphate levels. In all species, more efficient utilization of phosphate was observed with decreasing phosphate levels, together with reduced fresh shoot

ratio. Differences in growth rates could be related to differences in nutrient availability in the natural habitat.

29 (1983) Verhoeven J.T.A., S. van Beek, M. Dekker & W. Storm

Nutrient dynamics in small mesotrophic fens surrounded by cultivated land. I. Productivity and nutrient uptake by the vegetation in relation to the flow of eutrophicated ground water. Oecologia 60:25-33.

The effect of nutrient (N,P,K) transport from cultivated grassland to mesotrophic fen communities was studied. N and P proved to be limiting plant growth in the fens, whereas K was the main limiting fator in the hayfield. The groundwater welling up from the sandy bottom into the fens proved to be rich in ammonia. this leads to a considerable input of N into the fens, but for as yet not to a higher productivity, as the ammonia is absorbed by the deeper peat layers.

30 (1981) Andersen F.O.

Oxygen and nitrate respiration in a reed swamp sediment from a eutrophic lake.
Holarctic Ecol. 4:66-72.

In this study a comparison is made between the aerobic and the anaerobic mineralization by denitrification of organic carbon in a reed swamp sediment in a Danish eutrophic lake. On an annual basis nitrate respiration constituted 39% of total respiration, varying between zero in summer and 94% of the total carbon oxidation in winter.

31 (1980) Basilier K.

Fixation and uptake of nitrogen in *Sphagnum* blue-green algal associations.
Oikos 34:239-242.

Laboratory work on Sphagnum blue-green algal (Nostoc sp./Tolypothrix sp.) is described. The Sphagnum epiphytic algae have a considerable higher N2 fixation per heterocyst than

free algae in the same environment. The Sphagnum angustifolium stem transports nitrogen fixed and exuded by Nostoc muscorum upwards.

32 (1983) Brock Th.C.M., M.C.M. Bongaerts, G.J.M.A. Heijnen & J.H.F.G. Heijthuijsen

Nitrogen and phosphorus acumulation and cycling by *Nymphoides peltata* (Gmel.) O. Kuntze (*Menyanthaceae*).
Aquat. Bot. 17:189-214.

The seasonal changes in N and P concentrations of various plant parts of Nymphoides peltata, together with aspects of nitrogen and phosphorus cycling by this species were studied. The N and P stores of water, seston, sediment and macrophyte compartments were assessed each month. It is concluded that Nymphoides has the potential to function as an important N and P pump, which regenerates sediment nutrients.

33 (1983) Cuttle S.P.

Chemical properties of upland peats influencing the retention of phosphate and potassium ions.
J. Soil Sci. 34:75-82.

Study to establish the capacity of peat to retain phosphate and potassium ions following afforestation and application of fertilizers.

34 (1979) Filip Z.

Wechselwirkungen von Mikroorganismen und Tonmineralen - eine Übersicht.
[Relationships between soil microorganisms and clay minerals - a review.]
Z. Pflanzenernaehr. Bodenk. 142:375-386. (in German, English abstract)

Clay minerals belong to the most important factors in soils, influencing the composition and metabolic activity of soil microflora. their influence on bacteria, actinomycetes and

microscopic fungi is very complex and includes trophogenic relationships, cation exchange capacity, sorptive activity, osmotic and other physico-chemical effects in microbial environments. In this review, different effects of clay minerals on soil microorganisms and also the influence of microorganisms on the clay minerals are briefly discussed.

35 (1978) Szczepanski A.J.

Ecology of macrophytes in wetlands.
Pol. Ecol. Stud. 4:45-94.

Production of lake reed communities is analysed against the background of environmental conditions. Production characteristics of the reed has been determined, as has their relations to the habitat, as wel as the relationships between reed biology and biotic factors (competing plants, parasites, consumers). The role of reed communities in the functioning of lake ecosystems, the effect of reed on oxygen balance and nutrient cycling in the lake, as wel as water relationships in lakes are discussed. The economic importance of reed communities is characterized and conditions which should be met to avoid the destructive effect of exploitation on reed communities. The role of wetlands in maintaining the ecosphere balance is emphasized.

36 (1985) Marquenie J.M., D.K. Crawley, J.H. van Veen & H. Kerdijk

The effect on bioavailability of treatment of contaminated sediments with a hydrocyclone.
TNO report V14, Den Helder.

In cooperation with WES a mesocosmstudy was performed in which bioavailability of heavy metals and organic contaminants from harbour dredged sediments was studied in relation to bioturbation by the lugworm. Bioturbation leads to increased nutrient availability causing enhanced algal growth in the mesocosm, but no increase of bioavailability of contaminants was observed.

37 (1955) Malmer N. & H. Sjörs

Some determinations of elementary constituents in mire plants and peat.
Bot. Not. 108:46-80.

Samples of mire plants and peat samples were analysed for ash content, excess base of ash, N, P, K, S and other elements. As on 'normal' sites plants seem to be more or less undernourished, but compete successfully, it was suggested that growth and production is not solely decisive in explaining tolerances, reflected in establishment of floristic plant communities. The peat analyses indicate that a bog differs from a fen in N-K-Ca-Mg proportions, as well as in lower peat pH and lower content of several mineral substances. Most of these are highly concentrated absorbed to the peat, in comparison with the mire water. A considerable part of the total K in a mire is accumulated in living plants.

38 (1988) Ostendorp W.

Nährstoffkreisläufe und Nährstoffakkumulation in Seeufer-Schilfröhrichten. - Am Beispiel des Bodensee-Untersees. [Nutrient cycles and nutrient deposition in lakeside reedbelts - Exemplified by reeds of Lake Constance-Untersee.]
Telma 18:351-372. (in German, English abstract)

The carbon-, nitrogen- and phosphorous budgets of the lakeshore reedbelts of Lake Constance-Untersee have been estimated using field measurements and literature data from other areas and other marsh communities. Nitrogen turnover in these reedbelts is of the same order of magnitude as in paddy fields, but much less than in tidal North American Spartina marsh. The major N sources were found to be the ground water inflow from surrounding agricultural areas and the rainfall. The main P source was the detrital input by the inflow from the lake into the reeds. Atmospherical N and P should be sufficient to meet 2/3 of the nutrient requirements of a Phragmites stand. The most important N sink was denitrification; no assumptions could be made about the P sinks (except transfer to the peat layer). The yearly deposition of organic matter amounts to 4%, of N and P to 21% and 36%, respectively, of the total imput. The comparable high deposition rates of N are presumably due to the efficient transfer of microbially bound N to ligno-proteins in the humic fraction, phosphorous is fixed as insoluble inositol-phosphate and in stable Fe-P-humic acid complexes.

39 (1978) Dykyjova D. & J. Kvet (eds.)

Pond littoral ecosystems. Structure and functioning. Methods and results of quantitative ecosystem research in the Czechoslovakian IBP Wetland Project.
Ecological Studies 28. Springer-Verlag, Berlin. 464 pp.

The Czechoslovak IBP Wetlands project was focused on intensive quantitative ecological investigations of shallow littoral ecosystems of typical Central European fishponds, i.e. small man-made water bodies managed century-long for fish production. The results of the investigations summarized in this volume reflect several general aspects of wetland ecology. The volume does not present a final synthesis in the form of overall ecosystem budgets and models, but the editors have attempted to give as much as possible of condensed quantitative data as is needed for syntheses and ecosystem modelling.

40 (1988) Kuntze H.

Nährstoffdynamik der Niedermoore und Gewässereutrophierung. [Nutrient dynamics of fens and water eutrophication.]
Telma 18:61-72. (in German, English abstract)

The rehabilitation of hypertrophied shallow lakes in which more and more sludge accumulates will be successful only if the nutrient input from differnt sources might be reduced. during their formation by sedimentation and subsequent peat formation or peat formation on paludified soils fens are a sink for nutrient accumulating in the peat. Due to increasing drainage and intense farming they become however a source of remineralized nutrients. Based on long-term trials of the Institute for Soil Technology Bremen an account was given or the remineralizable quantities of NO3-N and PO4-P. More nutrients are mineralized by intense agricultural use of fen soils than might be withdrawn annually even by permanent grassland. Considering the relatively low leaching of nitrate and phosphate the importance of N-incorporation during humification as well as the denitrification during peat decomposition is discussed. P-leaching from soils into the ground water is similarly low as in mineral soils. the main task is above all to avoid a transfer into surface waters by erosion. Soil and water conservation means conservation of the peat substance. This demands a restricted intensity of land use.

41 (1991) Leonardson L.

Nitrogen retention in floating meadows: Denitrification studies.
Vatten 47:315-316.

Floating meadows, or flooded meadows, is a traditional method to improve grass production on grazing and hay meadows. The method allowed meadows to be fertilized with dissolved and particulate nutrients and prevented draughts. In southern Sweden investigations were undertaken into the nitrogen-retention potential of floating meadows duting 1990-1994, in order to reduce nitrogen run-off causing severe eutrophicational problems in the marine ecosystems surrounding Sweden.

42 (1994) Durka W., E.D. Schultze, G. Gebauer & S. Voerkelius

Effects of forest decline on uptake and leaching of deposited nitrate determined by 15N and 18O measurements
Nature 372: 765-767.

Ratio's of 15N and 18O were measured to establish the origin of nitrate in spring waters from eight forested watersheds in Bavaria (Germany), rauging from apparently healthy spruce plantations to those in decline owing to acidification. In healthy, slightly declining and limited sites, only 16-30% of the nitrate in spring waters originates directly from atmosphere, without being processed in the soil. At more severely damaged sites almost all of the atmospheric nitrate finds its way directly to the spring water, indicating reduced nitrate consumption by soil microorganisms and trees.

43 (1991) Lundin L.

Retention or loss of nitrogen in forest wetlands.
Vatten 47:301-304.

Review:
The increasing leaching of nitrogen to surface waters is an environmental hazard. This is especially evident in southern Sweden due to large nitrogen depositions and high nitrate

levels. From findings mainly in southern Sweden it has been postulated that denitrification may play an important role in decreased nitrogen leaching. However, these wetlands have to fulfill certain requirements that are not met to the same extent in middle and northern Sweden as in arable land in the south. Forest wetlands in middle and northern Sweden should not be relied upon as nitrogen sinks until the potentials are clarified. Indications of relatively high natural leaching from wetland type are found. Forest growth may particularly in these regions be the most important factor to reduce the nitrogen outflow from wetlands.

44 (1986) Malmer N.

Vegetational gradients in relation to environmental conditions in northwestern European mires.
Can. J. Bot. 64:375-383.

This paper discusses some ideas on interactions of plant cover and its environment in bogs and fens in relation to autogenous processes, based on studies in northwestern Europe. Special attention is given to the interactions among hydrology, decomposition of plant litter, and supply of inorganic plant nutrients in relation to the differences observed in plant cover. In the mire vegetation of northwestern Europe floristically characterized gradients can be recognized, related to mire surface microtopography, marginal versus central areas, ombrotrophy and minerotrophy, and distance from the sea. Within these gradients variations occur in oscillations in waterlevel, origin and flow of water and nutrient supply.

45 (1989) Brock Th.C.M. & R. Bregman

Periodicity in growth, productivity, nutrient content and decomposition of *Sphagnum recurvum var. mucronatum* in a fen woodland.
Oecologia 80:44-52.

Conditions in the understory of a Betula-carr appeared to be favourable for the growth of Sphagnum recurvum. The estimates of annual productivity and nutrient accumulation for S. recurvum obtained in this wetlands forest are in the high range of those reported for peatmosses. On an annual basis, the organic matter production , vegetative reproduction

(forking), and accumulation of N, P and K were very much the same for a relatively dry and for a relatively wet year. Periodicity in growth and length increase of the plants, however, differed remarkably between these years, and fruiting was observed in the dry year only. S. recurvum was characterized by a distinct variation in nutrient concentrations both with time and with distance from the capitulum. Organic weight loss during breakdown of S. recurvum in the wetland forest was low. Release of N, P and particularly K was larger than that of organic matter in decomposing S. recurvum. Nevertheless, a relatively large proportion of the original N and P stock remained associated with the peatmoss material after a 12month decay period. Observations with the scanning electron microscope revealed that after a year the cells of dead S. recurvum were hardly damaged and only poorly colonized by microorganisms. The characteristics of S. recurvum described here indicate its potency in directing succession in peatland forest.

46 (1980) Atwell B.J., M.T. Veerkamp, C.E.E. Stuiver & P.J.C. Kuiper

The uptake of phosphate by *Carex* species from oligotrophic to eutrophic swamp habitats. Physiol. Plant. 49:487-494.

Phosphate uptake of excised roots of 6 Carex species was compared. Species differed with respect to the nutrient availability in their natural habitat. The phosphate uptake was optimal at a pH of 4 indicating uptake of H2PO4. Compared with agricultural crops the P uptake of these wetland plants is verry efficient. this might indicate that in the waterlogged conditions under which the sedges grow and their extensive rootsystem, the uptake system is of more importance than the slow diffusion of P in soils.

47 (1992) Bernaldez F.G. & J.M. Rey Benayas

Geochemical relationships between groundwater and wetland soils and their effects on vegetation in central Spain.
Geoderma 55:273-288.

Groundwater hydrochemistry and topography are the main factors affecting wetland soils and the vegetation in the semi-arid area under study. Factor analysis reveals two major trends in the chemical evolution of groundwater: (1) increasing salinity with 'flow length'

and (2) alkalinization, with consequent effects on the chemical characteristics of the soil. The distribution of plant species is correlated with the alkalinity and salinity of the soils.

48 (1986) Heckman C.W.

The role of marsh plants in the transport of nutrients as shown by a quatitative model for the freshwater section of the Elbe estuary.
Aquat. Bot. 25:139-151.

Nitrogen and phosphorous is moved landwards by the tides which transport the detritus, produced when emergent parts of marsh plants die off in autumn. This way N and P are removed from the aquatic system and transported to the terrestrial part of the floodplain. Freshwater part of the Elbe estuary.

49 (1991) Groot C.J. de

The influence of FeS on the inorganic phosphate system in sediments.
Verh. Int. Ver. Limnol. 24:3029-3035.

The release of orthophosphate following reduction of Fe(OOH)-P is limited due to the formation of an iron-phosphate salt (FePO4 or Fe3(PO4)2). The changes in quantity of Fe(OOH) and consequent o-P fluxes between different inorganic phosphate pools may be expected to be more important in shallow lakes than in deeper lakes.

50 (1977) Lijklema L.

The role of iron in the exchange of phosphate between water and sediments.
In: H.L. Golterman (ed.), Interactions between sediments and freshwater. Dr. W. Junk Publishers, The Hague - Pudoc, Wageningen. pp. 313-317.

Review describing the relation between iron and phosphate in sediment. The release of phosphate is influenced by iron content, pH and aeration.

51 (1962) Persson A.

Mire and spring vegetation in an area north of Lake Torneträsk, Torne Lappmark, Sweden.
II. Habitat
conditions.
Opera Botanica 6(3). 100 pp.

The composition of the vegetation of a Swedish fen is compared with that of a spring. Differences are related to differences in water chemistry and nutrients.

52 (1986) Sly P.G. (ed.)

Sediments and water interactions.
Proceedings of the Third International Symposium on Interactions Between Sediments and Water, Geneva, Switzerland, August 27-31, 1984. Springer-Verlag, New York.

Proceedings of the Third International Symposium on Interactions between Sediments and Water, held in Geneva, Switserland, August 27-31, 1984. Relevant chapters are considered separately.

53 (1980) Sonesson M. (ed.)

Ecology of a subarctic mire.
Swedish Natural Science Research Council, Ecological Bulletins 30. 313 pp.

The papers in this volume deal with the structure and processes of a mire ecosystem under extreme environmental conditions. The mire is situated near Abisko, North Sweden, and represents a type of tundra on permafrost characteristic of the subarctic parts of Fennoscandia. It was therefore chosen in 1969 as one of the sites for the ecological tundra investigations of the International Biological Programme (1964-1974). The research, carried out according to internationally decided guide-lines, aimed at obtaining better knowledge of the ecological base for productivity of the whole circumpolar tundra relevant to the needs of man. Apart from the papers in the present volume, some individual works have been published and data from the Swedish project have also been used in international

synthesis. A complete list of references to previous publications relating to the project may be found in an appendix.
Relevant chapters are considered separately.

54 (1992) Verhoeven J.T.A. (ed.)

Fens and bogs in the Netherlands: Vegetation, history, nutrient dynamics and conservation. Geobotany 18, Kluwer Academic Publishers, Dordrecht.

Description of geologic and land-use history of dutch mires (ch.2-4), and details of present-day mire vegetation, synecology and management (ch.5-10). Chapter 9 seperately reviewed under no. 119.

55 (1962) Malmer N.

Studies on mire vegetation in the Archaean area of southwestern Götaland (south Sweden). I. Vegetation and habitat conditions on the Akhult mire.
Opera Botanica 7(1). 322 pp.

Description of the mire vegetation in southern Sweden in relation to hydrological gradients and water chemistry. Special emphasis is given to the Akkult mire.

56 (1962) Malmer N.

Studies on mire vegetation in the Archaean area of southwestern Götaland (south Sweden). II. Distribution and seasonal variation in elementary constituents on some mire sites.
Opera Botanica 7(2). 67 pp.

Comparison of mire vegetation and environmental variables in five mires in southern Sweden.

57 (1970) Saebo S.

The autecology of *Rubus chamaemorus* L. II. Nitrogen economy of *Rubus chamaemorus* in an ombotrophic mire.
Meld. Norges Landbrukshögsk. 49. 37 pp.

This report describes observations and experiments on nitrogen utilization and cycling in Sphagnum fuscum peat and in Rubus chamaemonus growing in Sphagnum peat under ombotrophic conditions. Ammonium ions are thought to be the only important nitrogen source in the investigated peat.

58 (1968) Saebo S.

The autecology of *Rubus chamaemorus* L. I. Phosphorus economy of *Rubus chamaemorus* in an ombotrophic mire.
Meld. Norges Landbrukshögsk. 47. 67 pp.

This report describes observations and experiments on phosphorous utilization and cycling in Sphagnum fuscum peat and in Rubus chamaemorus growing in Sphagnum peat under ombotrophic conditions

59 (1973) Gerlach A.

Methodische Untersuchungen zur Bestimmung der Stickstoffnettomineralisation. [Methodical investigations to determine nitrogen net mineralization.]
Scripta Geobotanica 5. 115 pp. (in German, English abstract)

Several methods to determine nitrogen net mineralisation in soil were compared. Field methods as well as laboratory methods. Not especially applied to wetland soils.

60 (1989) Koerselman W.

Hydrology and nutrient budgets of fens in an agricultural landscape.
Ph.D. Thesis University of Utrecht. 164 pp.

This thesis focusses on the relation between fen vegetation and nutrient mass balances in two fens in the Netherlands.
Chapter 2 deals with the modelling of the evaporation process, as part of a study on the hydrologic budget.
Chapter 3 (=63) describes in much detail the methodology used to calculate the individual water budget parameters, as well as an error analysis with respect to water budgets.
Chapter 4 deals with gaseous nitrogen fluxes in fens, denitrification and dinitrification fixation.
Chapter 5 (=62) contains complete hydrologic budgets and mass balances for nitrogen, phosphorous and potassium.
Chapter 6 (=61) considers the relation between the hydrologic regime of the fens and the chemical composition of the fen water. The focus of the chapter is on the effect that infiltration of river water has on the biogeochemistry of the two fens.
Chapter 7 combines data from foregoing chapters with data on patterns of internal cycling of nutrients. The objective is to summarize our current understanding of the relationship between the successional status of fens, hydrology, and nutrient dynamics in terms of the three fen types distinguished by Verhoeven et al (1988*a)*

61 (1990) Koerselman W., D. Claessens, P. ten Den & E. van Winden

Dynamic hydrochemical and vegetation gradients in fens.
Wetl. Ecol. Manage. 1:73-84.

Chapter 6 in thesis (60)
The mixing of groundwater, riverwater and precipitation was studied in a discharge fen and a recharge fen. The aim of the study was to characterize relationships between vegetation in fens, chemical composition of the fenwater, and the hydrological regimes. Analysis were made of the Ionic Ratio and Electrical Conductivity indices of the relative importance of the three main water sources.

62 (1990) Koerselman W., S.A. Bakker & M. Blom

Nitrogen, phosphorus and potassium budgets for two small fens surrounded by heavily fertilized
pastures.
J. Ecol. 78:428-442.

Chapter 5 in thesis (60).
Hydrological and nutrient budgets were measured in two fens from 1985 to 1987. One fen received polluted river water which compensated for evaporation and groundwater losses during summer. Although nutrient imputs, especially nitrogen, were enhanced as a result of agricultural activities, summer harvesting of above-ground biomass resulted in a net loss of potassium and phosphorous from the fens. Nitrogen inputs almost equalled outputs. Young fens are primarily fed by external nutrient inputs and are characterized by nutrient accumulation in peat. in mature fens, the peat isolates the fen from its environment and plant growth is driven by remineralization of nutrients.

63 (1989) Koerselman W.

Groundwater and surface water hydrology of a small groundwater-fed fen.
Wetl. Ecol. Manage. 1:31-43.

Chapter 3 in thesis (60)
The hydrology of a small qualing fen was investigated by measuring all components of the water budget. Two approaches for calculation of groundwater and surface water terms were compared.

64 (1980) Svensson B.H.

Carbon dioxide and methane fluxes from the ombrotrophic parts of a subarctic mire.
In: M. Sonesson (ed.), Ecology of a subarctic mire. Ecological Bulletins (Stockholm) 30:235-250.

At a subarctic mire in North Sweden carbondioxide and methane fluxes to the atmosphere were studied in relation to temperature and moisture. Annual methane flux was estimated to be 0.6g. $C/m^2/y$, which is 1.8% of the total carbon flux.

65 (1980) Rosswall T. & U. Granhall

Nitrogen cycling in a subarctic ombrotrophic mire.
In: M. Sonesson (ed.), Ecology of a subarctic mire. Ecological Bulletins (Stockholm) 30:209-234.

Data on nitrogen cycling in an ombrotropic, subarctic mire are presented. The system accumulates N at a rate of approximately 0.42g $N/m^2/y$, which is supplied through nitrogen fixation (0.2g), dry deposition (0.13g) and wet deposition (0.09g). The low pH prevents the occurrence of ammonia volatization, nitrification and denitrification. The turnover time of N was estimated to be 0.28 yr in microbial biomass, 9.3 yr in primary producers and 280 yr in peat. Compared to the other studies, the system is conservative in cycling N, with very closed internal cycles, indicating that easily available N is an important limiting factor for tundra ecosystems.

66 (1980)Sonesson M., S. Persson, K. Basilier & T.A. Stenström

Growth of *Sphagnum riparium* Angstr. in relaation to some environmental factors in the Stordalen
mire.
In: M. Sonesson (ed.), Ecology of a subarctic mire. Ecological Bulletins (Stockholm) 30:191-207.

The growth of Sphagnum riparium was studied in relation to light, temperature and nutrients in a field experiment in a tundra mire. The study showed that plants rapidly responded to changes in environmental conditions. Nutrients, possibly with exception of nitrogen due to fixation by epiphytic blue-green algae, are the primary growth limiting factor.

67 (1980) Kvillner E. & M. Sonesson

Plant distribution and environment of a subarctic mire.
In: M. Sonesson (ed.), Ecology of a subarctic mire. Ecological Bulletins (Stockholm) 30:97-111.

Principal components analysis (PCA) ordination was used to study the distribution of plant species and plant communities in relation to some environmental variables in a subarctic mire in north Sweden

68 (1980) Malmer N. & B. Nihlgard

Supply and transport of mineral nutrients in a subarctic mire.
In: M. Sonesson (ed.), Ecology of a subarctic mire. Ecological Bulletins (Stockholm) 30:63-95.

For K, Ca and Mg, the annual supply in precipitation can account for uptake in plant species in an ombrotrophic mire. For N and P the supply in precipitation is sufficient and the rest seems to be derived from decomposition of above-ground vascular plant litter and from other microbial activities.

69 (1994) Dorge J.

Modelling nitrogen transformations in freshwater wetlands. Estimating nitrogen retention and removal in natural wetlands in relation to their hydrology and nutrient loadings.
Ecol. Modell. 75/76:409-420.

A general simulation model has been developed for freshwater wetlands to determine the retention and removal of nitrogen in wetlands as water flows from intensively cultivated farmland through wetlands and into the aquatic system. The model consists of a simple hydrological submodel and a more complex biological submodel, including heterotrophic nitrogen dynamics and plant uptake.

70 (1993) Hillbricht-Ilkowska A.

The dynamics and retention of phosphorus in lentic and lotic patches of two river-lake systems.
Hydrobiologia 251:257-268.

The concentration of total and dissolved phosphorous was analysed at several places in two river-lake systems in Poland. Patches which act as sources occur alternatively with patches which are P-sinks, making the whole system more or less balanced with respect to P movement.

71 (1993) Cristofor S., A. Vadineanu & G. Ignat

Importance of flood zones for nitrogen and phosphorus dynamics in the Danube Delta.
Hydrobiologia 251:143-148.

Measurement of total reactive phosphorous and dissolved inorganic nitrogen in several parts of the Danube Delta near the Black Sea, show that nutrient retention is highest during periods of low and average water level. The retention of nutrients is higher in the wetland proper than in the river canals.

72 (1993) Pieczynska E.

Detritus and nutrient dynamics in the shore zone of lakes: A review.
Hydrobiologia 251:49-58.

This review discusses the importance of detritus in shore zones of lakes. Macrophytes and sediments appear to be the dominant stores of nutrients in these habitats, whereby macrophytes hold a central position in nutrient cycling.

73 (1993) Donk E. van, R.D. Gulati, A. Iedema & J.T. Meulemans

Macrophyte-related shifts in the nitrogen and phosphorus contents of the different trophic levels in a biomanipulated shallow lake.
Hydrobiologia 251:19-26.

To assess the effect of biomanipulation on the recovery of a small eutrophied lake, the fish community of the lake was changed by removing sediment-dwellers and zooplankton-eaters. As a result of the biomanipulation the lake switched from a turbid state (dominated by phytoplankton) to a clear water state (dominated by macrophytes).The macrophytes had a stabilizing function, acting as a sink for N and P and therefore changed the nutrient retention and cycling in the foodweb.

74 (1993) Kühl H. & J.G. Kohl

Seasonal nitrogen dynamics in reed beds (*Phragmites australis* (Cav.) Trin. ex. Steudel) in relation to productivity.
Hydrobiologia 251:1-12.

Reed-belt decline is a widely occurring phenomenon, especially within Phragmites australis stands. It is concluded that the increased nitrogen loads is at least one of the factors causing instability and reed-belt decline, due to a delayed shift from the vegetative to the generative phase reducing translocation of reserve material to the rhizome.

75 (1953) Gorham E.

A note on the acidity and base status of raised and blanket bogs.
J. Ecol. 41:153-156.

Analyses of surface peat were made in order to explain the dominance of Schoenus nigricans and Molina caerulea in the blanket bogs of western Ireland, instead of Sphagnum and Calluna vulgaris dominating the raised bogs in the less oceanic sites. As the % base saturation in the blanket bogs was relatively high it was concluded that sea-spray might have a great influence, which is concurrent which the higher chloride content measured.

However, it is suggested that also the mildness of the climate might be a factor allowing Schoenus to grow in habitats less base-rich than it commonly frequents elsewhere.

76 (1953) Gorham E.

Chemical studies on the soils and vegetation of waterlogged habitats in the English Lake District.
J. Ecol. 41:345-360.

A largely exploratory study was made of the chemical properties of the soils and vegetation in areas representative of the various successional stages in the development of raised bogs from aquatic and semi-aquatic habitats. In passing from relatively inorganic lake muds through semi-aquatic soils to raised bog peats, the amount of soil acid increases, base saturation declines, and humus nitrogen also falls.The changes are most marked at the transition from semi-aquatic to raised bog peats. These changes are reflected in the nutrient status of the plants, those from underwater sites being highest in minerals and nitrogen, and those from raised bogs lowest.

77 (1990) Hosper S.H. & E. Jagtman

Biomanipulation additional to nutrient control for restoration of shallow lakes in the Netherlands.
The Utrecht Plant Ecology News Report 11:130-146 / Hydrobiologia 200/201:523-533.

Although, as a result of international action programmes, the average phosphorus loadings of freshwater systems should decrease by 50% between 1985 and 1995, recovery of water quality is hampered by the structure and functioning of the present food-chain.The feeding behaviour of the dominant fish species in shallow dutch lakes, bream and roach, tend to impose a homeostasis on the system. This paper discusses whether a shift from 'turbid water' to 'clear water' will occur when fish stocks are drastically reduced and whether the new situation will be stable.

78 (1990) Koerselman W.

Bepaling van de efficientie van moerassen met betrekking tot de verwijdering van nutrienten. [Assessment of nutrient removal efficiency in wetlands.]
The Utrecht Plant Ecology News Report 11:22-43. (in Dutch, English summary)

Review:
The nitrogen and phosphorus removal efficiency of wetlands used for wastewater treatment can only be assessed when data on the complete mass balance of N and P are available. In this paper,the methodology to assess the various nutrient inputs and outputs and nutrient removal efficiency is discussed, with special attention to the compilation of the water budget.

79 (1990) Lijklema L.

Mass balances and cycling of nitrogen and phosphorus in flooded soils.
The Utrecht Plant Ecology News Report 11:44-51.

A review of the potential of wetlands for wastewater treatment. It is emphasised that only newly contructed wetlands have a high potential for retainment of nutrients due to the absorption capacity of original sediment, but that upon progressive dilution with fresh organic material this capacity decreases within a limited number of years. Furthermore a high rate of nutrient accumulation only occurs during the growing season of the vegetation. During late fall and winter the sediments are frequently a source of nutrients rather than a store.

80 (1990) Verhoeven J.T.A.

De nutrientenhuishouding van zoetwatermoerassen, speciaal met betrekking tot verrijking. [Nutrient dynamics of freshwater wetlands, with special reference to enrichment.]
The Utrecht Plant Ecology News Report 11:5-21. (in Dutch, English summary)

A review of nutrient dynamics in wetlands with special attention to relevance for wastewater treatment.

81 (1954) Tamm C.O.

Some observations on the nutrient turn-over in a bog community dominated by *Eriophorum vaginatum* L.
Oikos 5:189-194.

Some preliminary data on a fertilization experiment on a bog are presented. Phosphorus seems the only nutrient limiting for the bog vegetation. It stimulated growth of the vegetation and P-content of the plants increased. The N-content of the plant increased after fertilization with other elements.

82 (1987) Verhoeven J.T.A. & H.H.M. Arts

Nutrient dynamics in small mesotrophic fens surrounded by cultivated land. II. N and P accumulation in plant biomass in relation to the release of inorganic N and P in the peat soil.
Oecologia 72:557-561.

Release of inorganic N and P in the organic soils of three small quaking fens was studied by means of in situ incubation of the peat soil in plastic bottles. One of the fens was located in an area with downward groundwater perculation. It had a higher biomass production and lower species richeness than the other two fens. Mineralization and release of inorganic P were considerable higher in this fen.

83 (1991) Golterman H.L.

Influence of FeS on denitrification in shallow waters.
Verh. Int. Ver. Limnol. 24:3025-3028.

Laboratory experiments demonstrated the influence of FeS on denitrification in lake sediments. FeS couples denitrification and phosphate adsorption onto sediments, while the sulphide reflects the occurrence of organic matter in sediment

84 (1985) Winter M. & R. Kickuth

Elimination of nutrients (sulphur, phosphorus, nitrogen) by the root zone process and simultaneous degradation of organic matter.
The Utrecht Plant Ecology News Report 4:123-140.

Although much attention is given to the removal of N and P from wastewater, sulfurous compounds may play an important role in eutrophicational problems. This review discribes processes in the root zone that are important in removal of sulfurous compounds and the influence of sulfurous compounds on N and P cycling.

85 (1993) Koerselman W., M.B. van Kerkhoven & J.T.A. Verhoeven

Release of inorganic N, P and K in peat soils; effect of temperature, water chemistry and water level.
Biogeochemistry 20:63-81.

Nutrient release rates (N, P and K) were measured in sediment cores taken from Sphagnum peat and Carex peat. The cores were saturated in artificial media created to mimic the three basic water sources: polluted river water, unpolluted calcium-rich groundwater and rainwater. Additionally the effect of temperature and waterlevel on nutrient release rates was studied. In all treatments Sphagnum peat released more P and ammonium than Carex peat, which indicates soil quality may be the most important agent determining nutrient release rates. However, water chemistry and water level are also of significant influence on nutrient release rates, river water strongly stimulated P release by the peat, probably due to the high sulfate content of the water. The net release of ammonium, potassium and phosphate increased with increasing temperature, and also as a result of freezing.

86 (1993) Haycock N.E. & G. Pinay

Groundwater nitrate dynamics in grass and poplar vegetated riparian buffer strips during the winter.
J. Environ. Qual. 22:273-278.

Nitrate retention was measured during the winterr season in a grass (Lolium) and a poplar (Populus) vegetated riparian buffer strip. Nitrate retention mainly occurred in the first 5 meter and was linearly dependent on load rate. The poplar strip retained 99% of the nitrate, the grass strip 84%. Although vegetation has no active role in retaining nitrate in winter, above-ground biomass does contribute to soil microbacterial biomass that is engaged in nitrate reduction in the winter months.

87 (1979) Blackburn T.H.

Nitrogen/carbon ratios and rates of ammonia turnover in anoxic sediments.
In: A.W. Bourquin & P.H. Pritchard (eds.), Proceedings of the workshop: Microbial degradation of pollutants in marine environments. Pensacola Beach, Florida, 9-14 April 1978. EPA-600/9-79-012. pp. 148-190.

The net rate of ammonia production was measured in coastal sediment sections, at in-situ temperatures. Addition of 15N-labelled ammonia made possible the measurement of total ammonia turnover and of ammonia incorporation into cells. The molar N/C ratio in detrital material undergoing breakdown and the rate of carbon oxidation or sulfate reduction were calculated. The calculated values did not always correspond to the actual N/C ratio of the organic detritus in the sediment. The data are consistent with the hypothesis that surface detritus of an initially high N/C ratio progressively loses nitrogen as it is mixed downwards and finally results in a net uptake of ammonia in the lower sediment strata.

88 (1986) Klapwijk S.P. & C. Bruning

Available phosphorus in the sediments of eight lakes in the Netherlands.
In: P.G. Sly (ed.), Sediments and water interactions. Springer-Verlag, New York. pp. 391-398.

To estimate the release of phosphate from sediments sampled in eight lakes in the Netherlands, algae were grown in a medium with sediment as the sole source of P, and all other nutrients in excess.

89 (1986) Jansson M.

Nitrate as a catalyst for phosphorus mobilization in sediments.
In: P.G. Sly (ed.), Sediments and water interactions. Springer-Verlag, New York. pp. 387-389.

The influence of nitrate on anaerobic phosphorus release from lake sediments was studied in laboratory experiments. There was a clear positive correlation between nitrate concentration and the rate at which phosphorus was transformed from particulate to dissolved form. The use of 32P-labelled compounds confirmed that particulate iron-phosphorus associates were the origin of dissolved phosphorus. A possible explanation for stimulating effect of nitrate on phosphorus increases activity of nitrate reducing bacteria, which (after exhaustion of nitrate) utilize iron as an electron acceptor. This should cause iron and phosphorus to be released.

90 (1986) Balzer W., F. Pollehne & H. Erlenkeuser

Cycling of organic carbon in a coastal marine system.
In: P.G. Sly (ed.), Sediments and water interactions. Springer-Verlag, New York. pp. 325-330.

A carbon (C) budget in terms of input to the sediment, degradation of organic matter in surficial sediments, and accumulation in the sediment column was constructed for a representative area in the Kiel Bight.

91 (1986) Eck G.Th.M. van & J.G.C. Smits

Calculation of nutrient fluxes across the sediment-water interface in shallow lakes.
In: P.G. Sly (ed.), Sediments and water interactions. Springer-Verlag, New York. pp. 189-301.

Description of the mathematical model SEDMOD, developed within the framework of eutrophication research to describe the early diagnosis of nitrogen and phosphorus in recent lake sediments, and to calculate nutrient fluxes across the sediment-water interface.

92 (1986) Damiani V., E. Ambrosano, S. de Rosa, R. de Simone, O. Ferretti, G. Izzo & G. Zurlini

Sediments as a record of the input dispersal and settling processes in a coastal marine environment.
In: P.G. Sly (ed.), Sediments and water interactions. Springer-Verlag, New York. pp. 13-25.

The application of statistical techniques has demonstrated significant relationships between the terrestrial source environment and the receiving marine sedimentary environment.

93 (1980) Svenssen B.H. & T. Rosswall

Energy flow through the subarctic mire at Stordalen.
In: M. Sonesson (ed.), Ecology of a subarctic mire. Ecological Bulletins (Stockholm) 30:283-301.

Flows and storages of energy within the peat of a subarctic ombrotrophic mire in Sweden are given. The overall picture shows an accumulation of 1539 kJ/yr as soil organic matter, which is 44% of net primary production. To meet the production of microorganisms in the system and the soil respiration measured, the efficiency of bacteria and fungi must be high.

94 (1980) Ryden B.E. & L. Kostov

Thawing and freezing in tundra soils.
In: M. Sonesson (ed.), Ecology of a subarctic mire. Ecological Bulletins (Stockholm) 30:251-281.

Studies on freezing and thawing in the soil at a mire in the circumpolar zone of discontinuous permafrost. The analyses have shown relationships between thaw, thaw rate and environmental factors, such s meteorological conditions, microtopography and corresponding vegetation cover, and soil conditions.

95 (1985) Marquenie J.M., J.W. Simmers & E. Birnbaum

An evaluation of dredging in the Western Scheldt (the Netherlands) through bioassays.
TNO report R85/075.

Mesocosm study in cooperation wih WES. Main objective of the study was to establish bioavailability of contaminants in several dredged sediments to marine invertebrates. Additionally the influence of bioturbation by the lugworm on contaminant and nutrient availability was considered. It was concluded that bioturbation did not enhance bioavailability of heavy metals and organic pollutants. Silicium concentrations in the water were increased as a result of bioturbation, but no influence on nitrate concentrations was observed.

96 (1989) Crawford R.M.M., C. Studer & K. Studer

Deprivation indifference as a survival strategy in competition: Advantages and disadvantages of anoxia tolerance in wetland vegetation.
Flora 182:189-201.

Ecophysiological study. Plant species with rhizomes that survive prolonged periods of anoxia can have a competitive advance on species whose rhizomes can not withstand anoxia. Results are discussed in relation to theories on competition by Grime, Tilman and Grubb.

97 (1993) Koerselman W. & J. Verhoeven

Eutrofiering en laagvenen. Interne of externe oorzaken?
Landschap 10(4):31-44. (in Dutch)

Review:
Describes the difference between external eutrophication (input of external nutrients into wetland) and internal eutrophication (increasing availability of nutrients already present in the wetland), their relative importance in different types of peatbogs and finally how recovery of eutrophicated lowland peatbogs can be recovered.

98 (1988) Andersson G., W. Granéli & J. Stenson

The influence of animals on phosphorus cycling in lake ecosystems.
Hydrobiologia 170:267-284.

Reviews the cycling of phosphorus through the foodchain in lake ecosystems.

99 (1988) Jansson M.

Phosphate uptake and utilization by bacteria and algae.
Hydrobiologia 170:177-189.

Review of phosphorus uptake by bacteria and algae in lake water. Bacteria are more efficient in utilizing low phosphate concentrations than algae. However, even in the most oligotrophic waters the major shore of biologically bound phosphorus is found in algae. Theory explaining how algae obtain their phosphorus are discussed.

100 (1992) Golterman H.L.

Wetlands as nutrient buffers between continental and marine waters.
Avan. Oceanol. Med. Bull. Inst. Oceanogr. Mon. Spec. 11:75-87.

Synthesis and discussion of research on nutrient cycles/budgets in the Camarque region, a shallow freshwater wetland in the mediterranean order in southern France.

101 (1984) Kristensen E.

Effect of natural concentrations on nutrient exchange between a polychaete burrow in estuarine sediment and the overlying water.
J. Exp. Mar. Biol. Ecol. 75:171-190.

Marine.
Influence of Nereis on N and P fluxes.

102 (1991) Hemminga M.A., P.G. Harrison & F. van Lent

The balance of nutrient losses and gains in seagrass meadows.
Mar. Ecol. Prog. Ser. 71:85-96.
Review concerning nutrient cycling in seagrass meadows. Special attention is given to uptake and loss (by decomposition) of nutrients by seagrasses themselves.

103 (1990) Wiegers J.

Forest wetlands in Western Europe.
In: A.E. Lugo, S. Brown & M. Brinson (eds.), Forested wetlands. Ecosystems of the world. Vol. 15. Elsevier Amsterdam. pp. 407-436.

Review:
Very descriptive

104 (1994) Pelegri S.P., L.P. Nielsen & T.H. Blackburn

Dentrification in estuarine sediment stimulated by the irrigation activity of the amphipod Corophium volutator.
Mar. Ecol. Prog. Ser. 105:285-290.

Marine
Influence of Corophium on N-fluxes.

105 (1994) Jansson M., R. Andersson, H. Berggren & L. Leonardson

Wetlands and lakes as nitrogen traps.
Ambio 23:320-325.

Review of the role of nitrogen in eutrophication problems in Sweden. The efficiency of wetlands and lakes as nitrogen-traps is discussed.

106 (1994) Vought L.B.M., J. Dahl, C.L. Pedersen & J.O. Lacoursière

Nutrient retention in riparian ecotones.
Ambio 23:342-348.

Review of nitrogen retention and removal in riparian buffer strips along agricultural areas.

107 (1994) Fleischer S., A. Gustafson, A. Joelsson, J. Pansar & L. Stibe

Nitrogen removal in created ponds.
Ambio 23:349-357.

A study to establish the capacity of created ponds to remove nitrogen from water in order to decrease nitrogen runoff to coastal waters (i.e. the Baltic Sea)

108 (1994) Jacks G., A. Joelsson & S. Fleischer

Nitrogen retention in forest wetlands.
Ambio 23:358-362.

In fields studies the efficiency of forest wetlands as nitrogen traps was studied.

109 (1994) Weisner S.E.B., P.G. Eriksson, W. Granéli & L. Leonardson

Influence of macrophytes on nitrate removal in wetlands.
Ambio 23:363-366.

Review of the efficiency of emergent and submerged macrophytes on nitrogen removal in wetlands.

110 (1994) Ahlgren I., F. Sörensson, T. Waara & K. Vrede

Nitrogen budgets in relation to microbial transformations in lakes.
Ambio 23:367-377.

In two eutrophic lakes, microbial nitrogen budgets were measured and compared with nitrogen budgets based on inflow and outflow from lakes.

111 (1994) Arheimer B. & H.B. Wittgren

Modelling the effects of wetlands on regional nitrogen transport.
Ambio 23:378-386.

A 'dynamic conceptual model' is presented to simulate the hypothetical effect of wetlands on nitrogen export to the coastal zone

112 (1990) Wassen M.J.

Water flow as a major landscape ecological factor in fen development.
Ph.D. Thesis University of Utrecht.

This thesis examines the effects of water flow on habitat and species composition of fen plant communities. The main purpose was to investigate the causes of the deterioration of Caricion davallianae fens in the Netherlands.

113 (1991) Schot P.P.

Solute transport by groundwater flow to wetland ecosytems. The environmental impact of human activities.
Ph.D. Thesis University of Utrecht.

This thesis deals twith transport by groundwater flow and the way in which solute transport is affected by human activities. This in relation to wetland ecosystems influenced by human activities.

114 (1990) Kemmers R.H.

De stikstof- en fosforhuishouding van mesotrofe standplaatsen in relatie tot mogelijkheden van aanvoer van gebiedsvreemd water.
The Utrecht Plant Ecology News Report 10:7-22. (in Dutch, English Abstract)

Artificial water supply with surface water from polluted rivers is considered a better alternative than lowering of groundwater table, because the calcium rich groundwater can stil play a role in immobilizing phosphorus.

115 (1990) Meuleman A.F.M. & A. Sinke

De rol van sulfaatreduktie in de decompositie van organisch materiaal.
The Utrecht Plant Ecology News Report 10:23-38. (in Dutch)

Describes the role of sulfate reduction during decomposition of organic material

116 (1990) Cals M.J.R. & J.G.M. Roelofs

Mechanismen van interne eutrofiëring en alkalinisering.
The Utrecht Plant Ecology News Report 10:39-46. (in Dutch)

Describes the mechanism of internal eutrophication and the effects of alkaline water on the sulfur cycle in oligotrophic wetlands.

117 (1990) Oorschot M.M.P. van

De rol van de vegetatie bij het verwijderen van nutrienten uit water. (The role of the vegetation in nutrient removal from water).
The Utrecht Plant Ecology News Report 11:64-85. (in Dutch, English abstract)

In this review the use of wetlands for the removal of nutrients from waste water is considered. Processes in the cycling of nitrogen and phosphorus are considered, as well as the role of the macrophyte vegetation in the removal of nutrients.

118 (1970) Jones H.E. & J.R. Etherington

Comparative studies of plant growth and distribution in relation to waterlogging. I. The survival of Erica cinerea L. and E. tetralix L. and its apparent relationship to iron and manganese uptake in waterlogged soil.
J. Ecol. 58:487-496.

Growth and mortality of two species of Erica on waterlogged soils were compared in relation to the uptake of Fe and Mn.

119 (1992) Koerselman W. & J.T.A. Verhoeven

Nutrient dynamics in mires of various trophic status: Nutrient inputs and outputs and the internal nutrient cycle.
In: J.T.A. Verhoeven (ed.), Fens and bogs in the Netherlands: Vegetation, history, nutrient dynamics and conservation. Geobotany 18, Kluwer Academic Publishers, Dordrecht. pp. 397-432.

Describes the differrences in nutrient dynamics among mires. First the nutrient balance of N, P and K is reviewed. Subsequently the internal cycle of these elements in mire ecosystems is adressed and the uptake of these elements by fen vegetation and the degree to which they control plant growth are discussed. Mineralization studies in a range of different miretypes give further insight in the availability of N and P to the mire vegetation. Finally the major changes in nutrient dynamics that take place in the course of the long-term

succession in mires from open water areas via floating and quaking fens to poor fens and bogs are discussed.

120 (1993) Best E.P.H. & J.P. Bakker (eds.)

Netherlands-Wetlands.
Developments in Hydrobiology 88. Kluwer Academic Publishers, Dordrecht. - Hydrobiologia 265.

This book covers all Dutch wetlands, from fens and bogs to lakes and estuaries. Historical and present use and misuse are described, together with the possibilities for conservation and restoration. Nutrient dynamics are only described in a general manner, most attention is given to foodweb dynamics and hydrology. Most contributions are reviews, describing wetland types. Some contributions are case-studies emphasising management.

121 (1984) Moore P. (ed.)

European mires.
Academic Press, London.

An overview is given of European mires, and features upon which may be classified are described.

122 (1958) Malmer N.

Notes on the relation between the chemical composition of mire plants and peat.
Bot. Not. 111:274-283.

The chemical composition of simultaneously taken samples from substratum and plant at the same site from mires (fen/bog) is given.

123 (1950) Sjörs H.

On the relation between vegetation and electrolytes in north Swedish mire waters.
Oikos 2:241-258.

A division of vegetationgroups is made on the basis of their occurrence in pH- and conductivity range.

124 (1985) Dijk H.W.J. van, M.A.W. Noordervliet & W.T. de Groot

Nutrient supply of herbaceous bank vegetations in Dutch coastal dunes; the importance of nutrient mobilization in relation to (artificial) infiltration.
Acta Bot. Neerl. 34:301-319.

Plant species with extremely high nutrient demand grow abundantly on the banks of infiltration ponds in dune areas as a result of (artificial) infiltration with highly eutrophic water.

125 (1988) Aerts R. & F. Berendse

The effect of increased nutrient availability on vegetation dynamics in wet heathlands.
Vegetatio 76:63-69.

Fertilization of a wet heathland with N, P and K showed a decrease in percentage cover but not in biomass of Erica tetralix, whereas Molinia caerulea showed an increase in cover and biomass after fertilization with P.

126 (1992) Aerts R., B. Wall,n & N. Malmer

Growth-limiting nutrients in Sphagnum-dominated bogs subject to low and high atmospheric nitrogen supply.
J. Ecol. 80:131-140.

Determining growth limiting nutrients in Sphagnum-dominated bogs. In areas with high N-input, P was limiting. At a low natural N-input N was limiting. Natural N and P cycle was also studied.

127 (1988) Jerling L.

Population dynamics of Glaux maritima (L.) along a distributional cline.
Vegetatio 74:161-170.

Population dynamics of Glaux maritima was studied along a transect on a Baltic sea shore meadow between 1979 and 1983. The two maintenance systems of the species, vegetative propagation and sexual reproduction play different roles. Vegetative propagation is fast and responds quickly to variations in the environment. The seeds germinate in strongly fluctuating temperatures, which are triggered by disturbances such as flooding, damaging the vegetation.

128 (1988) Pehrsson O.

Effects of grazing and inundation on pasture quality and seed production in a salt marsh.
Vegetatio 74:113-124.

Changes in the composition of dominant plant species of importance to foraging birds in a salt marsh on the Swedish west coast were followed inside and outside exclosures at different hights relative to the water table to document effects of cattle grazing on herbage quality and seed production.

129 (1987) Braak C.J.F. ter & N.J.M. Gremmen

Ecological amplitudes of plant species and the internal consistency of Ellenberg's indicator values for moisture.
Vegetatio 69:79-87.

Ellenberg's moisture scale applied to indicate the wetness of soil on basis of phytosiciological data.

130 (1976) Ahmad I. & S.J. Wainwright

Ecotype differences in leaf surface properties of Agrostis stolonifera from salt marsh, spray zone and inland habitats.
New Phytol. 76:361-366.

Adaptation of Agrostis stolonifera to salt.

131 (1977) Ahmad I. & S.J. Wainwright

Tolerance to salt, partial anaerobiosis, and osmotic stress in Agrostis stolonifera.
New Phytol. 79:605-612.

Tolerance of Agrostis stolonifera clones from a saltmarsh, spray zone and inland habitats to salt, anaerobiosis and osmotic stress were established in a greenhouse study.

132 (1981) Bakker J.P. & J.C. Ruyter

Effects of five years of grazing on a salt-marsh vegetation.
Vegetatio 44:81-100.

Retogressive succession of salt marsh vegetation established from field studies at grazed and ungrazed salt marsh areas in the Netherlands.

133 (1971) Brereton A.J.

The structure of the species population in the initial stages of salt-marsh succession.
J. Ecol. 59:321-338.

Early succession of salt marshes explained on the basis of population dynamics of two colonisators: Puccinellia and Salicornia.

134 (1985) Beeftink A.

Interactions between Limonium vulgare and Plantago maritima in the Plantagini-Limonietum on the Boschplaat, Terschelling, The Netherlands.
Vegetatio 61:33-44.

Vegetation succession at salt marshes explained by competition between two species (Plantago, Limonium) in relation to life history characteristics.

135 (1985) Bakker J.P., M. Dijkstra & P.T. Russchen

Dispersal, germination and early establishment of halophytes and glycophytes on a grazed and abandoned salt-marsh gradient.
New Phytol. 101:291-308.

Dispersal of plant species along a salt marsh gradient under grazed and ungrazed conditions, explained on the basis of salt tolerance established in greenhouse experiments.

136 (1989) Hall P.O.J., L.G. Anderson, M.M. Rutgers van der Loeff, B. Sundby & S.F.G. Westerland

Oxygen uptake kinetics in the benthic boundary layer.
Limnol. Oceanogr. 34:734-746.

The uptake of oxygen by sediments was studied using flux-chambers. with radioactive tracers, the resistance of the boundary layer was estimated. A simple, one -dimensional transport, taking the diffusive limitation into account, agreed with the experimental data. Incubation experiments can be used to estimate sediment oxygen uptake.

137 (1981) Henriksen K., J.L. Hansen & T.H. Blackburn

Rates of nitrification, distribution of nitrifying bacteria, and nitrate fluxes in different types of sediment from Danish waters.
Mar. Biol. 61:299-304.

Nitrification was measured in different sediment types from Danish waters. There is no difference between sandy and muddy sediments. Nitrification is limited to the zone of oxygen penetration. However, there are also nitrifying bacteria found in the anoxia sediment layers. Their numbers were found by measuring the "nitrification potential".

138 (1980) Ignaciuk R. & J.A. Lee

The germination of four annual strand-line species.
New Phytol. 84:581-591.

Germination of strand-line species studied in relation to soil salinity

139 (1987) Robertson K.P. & S.J. Wainwright

Photosynthetic responses to salinity in two clones of Agrostis stolonifera.
Plant Cell Environ. 10:45-52.

Salinity tolerance of ecotypes of Agrostis stolonifera established from photosynthesis responses.

140 (1986) Jackson D., S.P. Long & C.F. Mason

Net primary production, decomposition and export of Spartina anglica on a Suffolk saltmarsh.
J. Ecol. 74:647-662.

Production and decomposition of Spartina biomass was measured from field observations.

141 (1979) Weihe K. von

Morphologische und ökologische Grundlagen der Vorlandsicherung durch Puccinellia maritima (Graminae).
Helgol. wiss. Meeresunters. 32:239-254.

Role of Puccinellia Maritima in the initial phase of salt marsh succession explained by responses to soil salinity characteristics.

142 (1987) Scholten M., P.A. Blaauw, M. Stroetenga & J. Rozema

The impact of competitive interactions on the growth and distribution of plant species in salt marshes.
In: A.H.L. Huiskes, C.W.P.M. Blom & J. Rozema (eds.), Vegetation between land and sea. Dr. W. Junk. Dordrecht. pp. 270-281.

The role of plant competition in salt marsh succession.

143 (1977) Rozema J. & B. Blom

Effects of salinity and inundation on the growth of Agrostis stolonifera and Juncus gerardii.
J. Ecol. 65:213-222.

Greenhouse studies to establish the tolerance of Agrostis and Juncus to salinityand inundation of the soil.

144 (1975) Rozema J.

An ecophysiological investigation into the salt tolerance of Glaux maritima L.
Acta Bot. Neerl. 24:407-416.

Greenhouse study to establish the salt tolerance of Glaux maritima.

145 (1985) Rozema J., E. Luppes & R. Broekman

Differential response of salt-marsh species to variation of iron and manganese.
Vegetatio 62:293-301.

Fe and Mn uptake is higher in salt marsh species that are sensitive to inundation in comparison to inundation tolerant species. This is explained by root porosity and radial oxygen loss.

146 (1978) Rozema J., E. Rozema-Dijst, A.H.J. Freijsen & J.J.L. Huber

Population differentiation within Festuca rubra L. with regard to soil salinity and soil water.
Oecologia 34:329-341.

Greenhouse study to compare tolerance of soil salinity and drought of a dune type and salt marsh type ecotype of the grass Festuca rubra.

147 (1956) Kaila A.

Phosphorus in virgin peat soils.
J. Sci. Agric. Soc. Finland 28:142-167.

Total phosphorus, organic phosphorus and the solubility of inorganic phosphorus was examined in some virgin peat soils in Finland.

148 (1994) Castella E., M.C.D. Speight, O. Obrdlik, E. Schneider & T. Lavery

A methodological approach to the use of terrestrial invertebrates for the assessment of alluvial wetlands.
Wetl. Ecol. Manage. 3:17-36.

In a correspondence analysis, 118 faunal species of the Loire-floodplain were related to habitat, moisture and substrate.

149 (1994) Denny P.

Biodiversity and Wetlands.
Wetl. Ecol. Manage. 3:55-61.

Wetland biodiversity, wetland values and classification strategy for wetland conservation is discussed, as implications of the Biodiversity Convention of the UNCED-Conference in Rio.

150 (1954) Kaila A., S. Soini & E. Kivinen

Influence of lime and fertilizers upon the mineralization of peat nitrogen in incubation experiments.
J. Sci. Agric. Soc. Finland 26:79-95.

The effect of addition of lime and fertilizers on the decomposition rate and nitrification of peat (fen-, bog-) soils was studied in laboratory incubation experiments. No significant positive effects were found after addition of lime on nutrients.

151 (1984) Schat H., A.H. Bos & M. Scholten

The mineral nutrition of some therophytes from oligotrophic dune slack soils.
Acta Oecol. Plant. 5:119-131.

Uptake of minerals by plant species from wel duneslacks.

152 (1987) Zahran M.A.

Comparative ecophysiological studies on Puccinellia maritima and Festuca rubra, Bank End coastal marsh, Irish Sea, England.
J. Coast. Res. 3:359-368.

Succession of salt marsh vegetation explained from ecological studies on a low and high salt marsh grass species.

153 (1985) Woodell S.R.J.

Salinity and seed germination patterns in coastal plants.
Vegetatio 61:223-229.

Germination behaviour in response to varying salinity conditions.

154 (1971) Tiku B.L. & R.W. Snaydon

Salinity tolerance within the grass species Agrostis stolonifera L.
Plant Soil 35:421-431.

Root elongation was found to be an inadequate measure of salinity tolerance of this grass species.

155 (1985) Schat H. & M. Scholten

Comparative population ecology of dune slack species; the relation between population stability and germination behaviour in brackish environments.
Vegetatio 61:189-195.

Tolerance of plant species from wel dune slacks to salinity: greenhouse experiments.

156 (1986) Schat H. & M. Scholten

Effects of salinity on growth, survival and life history of four short-lived pioneers from brackish dune slacks.
Acta Oecol. Plant. 7:221-231.

Tolerance of plant species from wet dune slacks to salinity, established in greenhouse experiments.

157 (1985) Rozema J., P. Bijwaard, G. Prast & R. Broekman

Ecophysiological adaptations of coastal halophytes from foredunes and salt marshes.
Vegetatio 62:499-522.

Review of salinity and inundation tolerance of salt marsh plant species.

158 (1985) Rozema J., R. Otte, R. Broekman & H. Punte

Accumulation of heavy metals in estuarine salt marsh sediment and uptake of heavy metals by salt marsh halophytes.
Proc. Int. Conf. Heavy metals in the environment, Athens 1985.

Uptake of metals in salt marsh plants collected from salt marshes in the Netherlands, in relation to various extract fractions of metals in the sediments.

159 (1981) Rozema J., H. Gude & G. Pollak

An ecophysiological study of the salt secretion of four halophytes.
New Phytol. 89:201-217.

Greenhouse studies regarding tolerance of salt marsh plant species to different chlorines (KCl, NaCl, CaCl2).

160 (1956) Gorham E. & W.H. Pearsall

Acidity, specific conductivity and calcium content of some bog and fen waters in northern Britain.
J. Ecol. 44:129-141.

Water samples taken from bog and fen water. Concentrations of H+ and Ca++ were measured, Sphagnum carpets positioned within this matrix. No discussion/conclussions.

161 (1950) Gorham E.

Variation in some chemical conditions along the borders of a Carex lasiocarpa fen community.
Oikos 2:217-240.

The range of chemical conditions (pH in water and peat; Ca, Na, K and conductivity in the water) along the borders of Carex lasiocarda was studied in a mire community. These conditions may in some locations be relatively constant, but in other situations they may vary widely.

162 (1953) Kaila A., J. Köylijärvi & E. Kivinen

Influence of temperature upon the mobilization of nitrogen in peat.
J. Sci. Agric. Soc. Finland 25:37-46.

The biological and chemical mobilization of nitrogen in peat was studied at various temperatures in laboratory experiments. Liming did not show any benificial effect upon the accumulation of mineral nitrogen.

163 (1983) Davies M.S. & A.K. Singh

Population differentiation in Festuca rubra L. and Agrostis stolonifera L. in response to soil waterlogging.
New Phytol. 94:573-583.

Laboratorium experiments with two grass species (Agrostis stolonifera, Festuca rubra) grown in drained and waterlogged soils. Differences in tolerances are explained by increased Fe and Mn in shoots of sensitive inland populations compared to tolerant salt marsh populations.

164 (1985) Jensen A.

On the ecophysiology of Halimione portulacoides.
Vegetatio 61:231-240.

Growth of Halimione is stimulated by moderate salinities, but depressed at high salinities of the soil. At higher salinities nitrate fertilization reduced salinity effect.

165 (1985) Groenedijk A.M.

Ecological consequences of tidal managment for the salt-marsh vegetation.
Vegetatio 62:415-424.

Field studies showed a negative effect of prolonged summer inundation due to waterworks on the salt marsh vegetation.

166 (1984) Groenedijk A.M.

Primary production of four dominant salt-marsh angiosperms in the SW Netherlands.
Vegetatio 57:143-152.

Primary production measurements of four dominant salt marsh plant species, with the recommendation to use a 'paired plot method' as the best approach to estimate actual above ground production.

167 (1944) Mattson S. & N. Karlsson

The pedography of hydrologic soil series: VI. The composition and base status of the vegetation in relation to the soil.
Kungl. Landbrukshögsk. Ann. 12:186-203. [Ann. Agric. Coll. Sweden]

The composition ('excess base', Ca, Mg, K, P, N, pH, acidity, % base saturation) of podzol, bog and bown earth-soils was determined, and related to the composition of 56 plant species.

168 (1957) Kivekäs J. & A. Kaila

Extractable calcium, magnesium, potassium and sodium in different peat types.
J. Sci. Agric. Soc. Finland 29:41-55.

The amount of plant-available Ca, K and Mg and pH was determined for Finnish virgin peat soil. There were no clear relations observed between the type of peat and the nutrient content.

169 (1993) Koncalova H., J. Kvet, J. Pokorny & V. Hauser

Effect of flooding with sewage water on three wetland sedges.
Wetl. Ecol. Manage. 2:199-211.

'Mesocosm experiment'
Carex species were cultivated and flooded with diluted 'pig farm'-sewage. Above-ground biomass increased, as well as nutrient concentrations. Differentiation of cell-structures in the root system decreased.

170 (1956) Kaila A.

Phosphorus in various depths of some virgin peat lands.
J. Sci. Agric. Soc. Finland 28:90-104.

Phosphorus concentrations of inland-peats were measured at various depths. Concentrations were very low (<0.1% DW). In deeper layers the fraction organic P raised, while solubility decreased.

171 (1977) Jefferies R.L. & N. Perkins

The effects on the vegetation of the additions of inorganic nutrients to salt marsh soils at Stifkey, Norfolk.
J. Ecol. 65:867-882.

Fertilization of field plots with nitrogen did not result in a significant response of many salt marsh species. Some slight changes in reproduction behaviour and competition were observed.

172 (1977) Jefferies R.L.

Growth responses of coastal halophytes to inorganic nitrogen.
J. Ecol. 65:847-865.

Experimental studies on the growth of salt marsh plant species to available nitrogen (nitrate, ammonium). Upper marsh species show less response, which is related to a low intrinsic growthrate (drought tolerance).

173 (1973) Stewart G.R., J.A. Lee & O.C. Orebamjo

Nitrogen metabolism of halophytes II Nitrate availibility and utilization.
New Phytol. 72:539-546.

Nitrate is the most important form of available nitrogen in this salt marsh. All salt marsh species can assimilate nitrate. There is a strong competition for nitrate, especially in the upper marsh. Nitrate supply from tides is available at the lower marsh.

174 (1979) Abd.Aziz S.A. & D.B. Nedwell

Microbial nitrogen transformations in the salt marsh environment.
In: R.I. Jefferies & A.J. Davy (eds.), Ecological processes in the coastal environments. Blackwell Oxford. pp. 385-398.

Only a small part of the organic nitrogen has been converted into inorganic nitrogen (viz. ammonium) in a British salt marsh. Nitrogen mineralization and uptake by plants are equal. Despite the high capacity for denitrification, this is a negligible process due to nitrate depletion. Nitrogen fixation is also negligible.

175 (1977) Henriksen K. & A. Jensen

Nitrogen mineralization in a salt marsh ecosystem dominated by Halimione portulacoides.
In: R.I. Jefferies & A.J. Davy (eds.), Ecological processes in the coastal environments. Blackwell Oxford. pp. 373-384.

Nitrogen mineralization at a Danish salt marsh: seasonal fluctuation. More than 80% is converted into nitrate.

176 (1977) Long S.P. & H.W. Woolhouse

Primary production in Spartina marshes.
In: R.I. Jefferies & A.J. Davy (eds.), Ecological processes in the coastal environments. Blackwell Oxford.

Model for estimating primary production of Spartina marshes, discussed in relation to the C3 metabolism.

177 (1977) Stewart G.R., F. Lahrer, I. Ahmad & J.A. Lee

Nitrogen metabolism and salt-tolerance in higher plant halophytes.
In: R.I. Jefferies & A.J. Davy (eds.), Ecological processes in the coastal environments. Blackwell Oxford.

A study on the accumulation of organic nitrogen compounds as osmotoc solutes determining the salt tolerance of halophytes in relation to NaCl accumulation.

178 (1969) Pigott C.D.

Influence of mineral nutrition on the zonation of flowering plants in coastal salt-marshes.
In: I.H. Rorison (ed.), Ecological aspects of the mineral nutrition of plants. Blackwell Oxford. pp. 25-35.

Nutrient uptake and growth response of salt marsh plant species grown at various zones in a salt marsh gradient.

179 (1988) Oenema O. & R.D. DeLaune

Accretion rates in salt marshes in the Eastern Scheldt, South-West Netherlands.
Est. Coast. Shelf Sci. 26:379-394.

Measurement of salt marsh sediment accretion on the basis of radioactive Cs.

180 (1992) Svensson B.H. & I. Sundh

Factors affecting methane production in peat soils.
Suo 43:183-190.

Factors affecting methane production in peat soils are reviewed. Two main factors are the water table level (restrict oxygen penetration) and the chemical characteristics of the peat material.

181 (1992) Clymo R.S.

Models of peat growth.
Suo 43:127-136.

Models describing peat accumulation at the surface of a peat-forming bog are given.

182 (1990) Straskraba M.

Shallow lakes and reservoirs.
In: B.C. Patten & S.E. Jorgensen (eds.), Wetlands and shallow water bodies. Vol. 1. SPB Academic Publishers, The Hague. pp. 425-444.

Management possibilities and utilization by man of shallow lakes and reservoirs is reviewed, including mathematical models for both theoretical understanding and as management tools.

183 (1986) Verhoeven J.T.A.

Nutrient dynamics in minerotrophic peat mires.
Aquat. Bot. 25:117-137.

Nutrient dynamics (N,P and K) in minerotrophic peat mires are reviewed. Nutrient stocks in three compartments, viz water, peat soil and vegetation are given for three mire systems in different parts of the world.

184 (1984) Malmer N. & E. Holm

Variation in the C/N-quotient of peat in relation to decomposition rate and age determination with 210Pb.
Oikos 43:171-182.

The C/N quotient of 0.5m cores of Swedish peat bogs is determined as a function of depth. It decreases because of the loss of C due to decay. Determination of age of peat using 210Pb and 14C.

185 (1990) Armentano T.V. & J.T.A. Verhoeven

Biogeochemical cycles: Global.
In: B.C. Patten & S.E. Jorgensen (eds.), Wetlands and shallow water bodies. Vol. 1. SPB Academic Publishers, The Hague. pp. 281-311.

Review discussing the importance of wetlands to the global cycles of C, N and S. (processes, balances, sinks, release)

186 (1992) Damman A.W.H., K. Tolonen & T. Sallantaus

Element retention and removal in ombrotrophic peat of Häädetkeidas, a boreal Finnish peat bog.
Suo 43:137-145.

Peat samples were taken to a depth of 5m. Plant composition and nutrient concentrations were determined to study uptake and cycling of these compounds in the past.

187 (1990) Junk W.J. & R.L. Welcomme

Floodplains.
In: B.C. Patten & S.E. Jorgensen (eds.), Wetlands and shallow water bodies. Vol. 1. SPB Academic Publishers, The Hague. pp. 491-524.

General review about floodplains, also including management.

188 (1990) Toorn J. van der, J.T.A. Verhoeven & R.L. Simpson

Fresh water marshes.
In: B.C. Patten & S.E. Jorgensen (eds.), Wetlands and shallow water bodies. Vol. 1. SPB Academic Publishers, The Hague. pp. 445-465.

Review describing ecffects of management options on both flora and fauna.

189 (1990) Brinkman R. & C.A. van Diepen

Mineral soils.
In: B.C. Patten & S.E. Jorgensen (eds.), Wetlands and shallow water bodies. Vol. 1. SPB Academic Publishers, The Hague. pp. 37-59.

Review about wetlands in general. Mondial distribution of wetlands and formation of wetland soils. Limited information about nutrients etc.

190 (1994) Franzén L.G.

Are wetlands the key to the ice-age cycle enigma?
Ambio 23:300-308.

Theoretical thesis on the relation between wetland dynamics and glacial cycles. Peat growth in temperate wetlands generates the ice-age cycle, while glaciations create suitable landscapes for wetland development.

191 (1991) Fleischer S., L. Stibe & L. Leonardson

Restoration of wetlands as a means of reducing nitrogen transport to coastal waters.
Ambio 20:271-272.

It is argued that wetland restoration can reduce the nitrogen transport to the seas, due to retention of nitrogen in wetland sediments and vegetation and due to denitrification.

192 (1988) Regnault M., R. Boucher-Rodoni, G. Boucher & P. Lasserre

Effects of macrofauna excretion and turbulence on inorganic nitrogenous exchanges at the water-sediment interface. Experimental approach in microcosms.
Cah. Biol. Mar. 29:427-444.

In presence of macrofauna (Carcinus and Crassostrea) the ammonium flux from marine sediments is 1-2 orders of magnitude higher than in the absence of macrofauna.

193 (1992) Karsisto M.

Microbiological and organic characterisation of peat.
Suo 43:217-220.

The organic and microbiological characterization of peat and methods are briefly outlined.

194 (1992) Sakovets V. & N.I. Germanova

Changes in the carbon balance of forested mires in Karelia due to drainage.
Suo 43:249-252.

Drainage of a pine fen mire resulted in an increased biomass despite loss of carbon in the peat.

195 (1992) Silvola J., P. Martikainen & H. Nykänen

A mobile automatic gas chromatograph system to measure CO2, CH4 and N2O fluxes from soil in the field.
Suo 43:263-266.

A mobile, automatic gas chromatograph system to measure CO2, CH4 and N2O-fluxes from soil in the field is tested on a virgin Sphagnum-fen in Finland.

196 (1992) Westermann P.

The effect of temperature on the metabolism of hydrogen and butyrate in a temperate swamp ecosystem.
Suo 43:289-292.

Investigation to the effect of substrate concentrations on the temperature sensitivity of methanogenesis and butyrate metabolism. The investigation was carried out with sediment slurries from a Red alder-waterlogged swamp.

197 (1991) Olsson H.

Materialbalanser för vänerns fosfor- och kvävetransporter 1970-1989. [Nitrogen and phosphorus mass balances for Lake Vänern 1970-1989.]
Vatten 47:263-272. (in Swedish, English abstract).

Phosphorus and nitrogen mass balances show that ca 70% of the total P input accumulates in the sediment, while 25-40% of the total N input was lost via sedimentation and denitrification.

198 (1983) Egloff Th.

Der Phosphor als primär limitierender Nährstoff in Streuwiesen (Molinion). Düngungsexperiment im unteren Reusstal. [Phosphorus as prime limiting nutrient in litter-meadows (Molinion). Fertilization experiment in the lower valley of the Reuss.]
Ber. Geobot. Inst. ETH, Stiftung Rübel 50:119-148. (in German, English abstract)

Phosphorus cycling in a wet meadow in Switzerland indicate that P is the prime limiting nutrient in these meadows. Not a real wetland.

199 (1989) Rydin H. & R.S. Clymo

Transport of carbon and phosphorus compounds about *Sphagnum.*
Proc. R. Soc. Lond. B 237:63-84.

A radioactive tracer experiment is conducted in order to explain the effective mechanism of C relocation in a Sphagnum.

200 (1983) Drew M.C.

Plant injury and adaptation to oxygen deficiency in the root environment: A review.
Plant Soil 75:179-199.

An excellent review on root dynamics in anaerobic soils

201 (1982) Armstrong W.

Waterlogged soils.
In: J.R. Etherington (ed.), Environmental plant ecology. John Wiley, Chichester. 2nd ed. pp. 290-330.pp.

An excellent review on physicochemical characters of wetland soils and subsequent responses and adaptations of wetland plants.

202 (1978) Weihe K. von

Untersuchungen zur Okologie von *Puccinellia maritima* (Huds.) Parl. (Temperatur und Meersalzwirkung).
Beitr. Biol. Pflanzen 54:145-163. (in German)

Phytotron and greenhouse studies on the tolerance of Puccinellia maritima to salinity

203 () Weihe K. von

Konkurrenzvorgange bei der Aussussung van Soden des *Puccinellion maritimae*.
??. (in German)

The effect of decreased salinity on the vegetation of salt marshes in Germany.

204 (1982) Cooper A.

The effects of salinity and waterlogging on the growth and cation uptake of salt marsh plants.
New Phytol. 90:263-275.

The uptake of cations under various conditions regarding salinity and waterlogging have been studied for a range of salt marsh species.

205 (1985) Flowers T.J.

Physiology of halophytes.
Plant Soil 89:41-56.

Physiological studies regarding salt-tolerance of halophylic plant species.

206 (1992) Martikainen P.J., H. Nykänen, P. Crill & J. Silvola

The effect of changing water table on methane fluxes at two Finnish mire sites.
Suo 43:237-240.

Methane fluxes were measured at a virgin and a designed site of a minerotrohopic fen and ombrotrophic peatbog. Draining lowered the CH4 production at the ombrotrophic site and changed the CH4 production in CH4 uptake at the minerotrophic site.

207 (1992) Dierendonck M.C. van

Simulation of peat accumulation: An aid in carbon cycling research?
Suo 43:203-206.

Primary production and accumulation of peats was compared among micro-sites and between various Sphagnum-species. Significant differences were found. A simulation model was constructed to predict primary production of peats.

208 (1992) Charman D.J., R. Aravena & B.G. Warner

Isotope geochemistry of gas and water samples from deep peats in boreal Canada.
Suo 43:199-201.

The age of CO2 and CH4 in deep samples from Canadian peat soils were determined. CO2 and CH4 are younger than the adjacent peat, suggesting complex carbon dynamics, possible due to insignificant vertical water movement.

209 (1992) Sundh I., M. Nilsson & B.H. Svensson

Depth distribution of methane production and oxidation in a Sphagnum peat bog.
Suo 43:267-269.

Incubation experiments with peat slurries from different depth layers collected from three different plant communities show that production and oxidation of methane are largely determined by the level of the water table.

210 (1988) Holtan H., L. Kamp-Nielsen & A.O. Stuanes

Phosphorus in soil, water and sediment: An overview.
Hydrobiologia 170:19-34.

Review of the geochemistry of different forms of phosphorus in sediments, waters and soils. Sorption and desorption processes are discussed in terms of algal growth due to phosphorus releases from sediments.

211 (1982) Jorgensen S.E., L. Kamp-Nielsen & H.F. Mejer

Comparison of a simple and a complex sediment phosphorus model.
Ecol. Modell. 16:99-124.

A model describing the phosphorus and oxygen conditions in lake sediments on basis of aerobic decomposition, diffusion, absorption, chemosorption, sedimentation and resuspension. Based on experimental data. The model does not fit better to observed values than a simple model published earlier.

212 (1992) Bakker J.F.

Biogeochemical processes in marine sediments with emphasis on the nitrogen cycle and oxygen dynamics.
Ph.D. Thesis, University of Groningen.

Thesis on the nitrogen cycle in marine sediments under various conditions regarding oxygen supply. Use of needle and microtype oxygen electrodes in order to study oxygen profiles and fluxes in sediment cores, and sediment incubator tests to study biochemical responses of sediment to changing oxygen conditions.

213 (1992) Ostergaard Andersen F. & E. Kristensen

The importance of benthic macrofauna in decomposition of microalgae in a coastal marine sediment.
Limnol. Oceanogr. 37:1392-1403.

Decomposition of organic matter was studied in marine benthic microcosms with and without fauna. The presence of surface deposit feeders stimulate mainly the decomposition of old and refractory sediment organic matter, but has no substantial influence on the decomposition of freshly sedimented organic matter.

214 (1994) Stockey A. & R. Hunt

Predicting secondary succession in wetland mesocosms on the basis of autecological information on seeds and seedlings.
J. Appl. Ecol. 31:543-559.

Mesocosms experiments regarding the competition between seedlings of wetland plant species in order to explain the early stages of wetland succession. Some recommendations for using seed mixtures when creating wetlands are given. It is emphasized that the initial phase of wetlands succession in important and determines the structure of created wetlands later on.

215 (1974) Ellenberg H.

Zeigerwerte der Gefässpflanzen Mitteleuropas. [Indicator values of vascular plants in Central Europe.]
Scripta Geobotanica 9. 97 pp. (in German, English abstract)

The traditional approach of Ellenberg, enabling an indication of the wetness (and other characteristics) of soils on the basis of the presence of certain indicator species of vascular plants. A "Feuchtzahl" between 8 and 11 indicates wetlands soils. A value of 12 is refers to submersed systems, a value below 7 refers to dry habitats. For a list of species the "Feuchtzahle" is given.

216 (1977) Rippey B.

The behaviour of phosphorus and silicon in undisturbed cores of Lough Neagh sediments.
In: H.L. Golterman (ed.), Interactions between sediments and freshwater. Dr. W. Junk Publishers, The Hague - Pudoc, Wageningen. pp. 348-353.

Phosphorus and silicon exchange was studied in sediment cores and suspensions from Lough Neagh.

217 (1977) Banoub M.W.

Experimental investigations on the release of phosphorus in relation to iron in freshwater/mud system.
In: H.L. Golterman (ed.), Interactions between sediments and freshwater. Dr. W. Junk Publishers, The Hague - Pudoc, Wageningen. pp. 324-330.

Study on the effects of soil characteristics (O2, Fe, etc) and microorganisms on the exchange of P between water and sediment.

218 (1977) Granéli W.

Sediment oxygen uptake in south swedish lakes.
In: H.L. Golterman (ed.), Interactions between sediments and freshwater. Dr. W. Junk Publishers, The Hague - Pudoc, Wageningen. pp. 276.

Study on oxygen uptake of sediment in shallow lakes. Oxygen demand is related to primary production.

219 (1977) Ryding S.O. & C. Forsberg

Sediments as nutrient source in shallow polluted lakes.
In: H.L. Golterman (ed.), Interactions between sediments and freshwater. Dr. W. Junk Publishers, The Hague - Pudoc, Wageningen. pp. 227-234.

Study on water/sediment nutrient fluxes in three shallow water lakes.

220 (1972) Mannerkoski H.

Microbiological changes in the humus layer of forest soils undergoing paludification.
In: Proceedings of the 4th international peat congress, Finland, 1972. Vol. 1. Virgin peatlands. Conservation, terminology. pp. 319-326.

Effects on microbial composition and CO2 production of forest soils undergoing paludification. Paludification decreased both processes.

221 (1992) Tolonen K., H. Vasander, A.W.H. Damman & R.S. Clymo

Preliminary estimate of long-term carbon accumulation and loss in 25 boreal peatlands.
Suo 43:277-280.

Study of organic material accumulation (using dating methods) in 25 peatland cores from Finland, Estonia and Maine (USA).

222 (1992) Silvola J., J. Alm & U. Ahlholm

The effect of plant roots on CO2 release from peat soil.
Suo 43:259-262.

The effect of plant roots on CO2 release from peat soil was studied in field and greenhouse experiments. In both experiments CO2 release was increased when living plants were present.

223 (1992) Sallantaus T.

Leaching in the material balance of peatlands - preliminary results.
Suo 43:253-258.

Study concerning leaching from drained and undrained peats. Nutrient concentrations were higher in water fluxes from drained areas.

224 (1990) Adam P.

Saltmarsh ecology.
Cambridge Studies in Ecology. Cambridge University Press, Cambridge. 461 pp.

Excellent book on salt marsh ecology.

226 (1990) P.E.J. Laan

Mechanisms of flood-tolerance in Rumex species.
Ph.D. Thesis, University of Nijmegen.

Adaptation of Rumex species to soil inundation, especially in relation to root porosity, root respiration and radial oxygen loss.

227 (1988) Diggelen J. van

A comparitive study on the ecophysiology of salt marsh halophytes.
Ph.D. Thesis, Free University Amsterdam.
A thesis on the ecophysiological adaptations of various salt marsh plant species to low redox potentials (including ferrous iron and sulphide stress).

228 (1993) Buth G.J.C.

Decomposition and primary production in salt marshes.
Ph.D. Thesis, University of Utrecht.

Thesis on organic matter production and decomposition at salt marshes in the Netherlands.

229 (1991) Otte M.R.

Heavy metals and arsenic in vegetation of salt marshes and floodplains.
Ph.D. Thesis, Free University Amsterdam.

Thesis on the uptake of metals by marsh plants in relation to metal content of soils, extractable fractions, soil redox potential and radial oxygen loss.

230 (1978) Rozema J.

On the ecology of some halophytes from a beach plain in the Netherlands.
Ph.D. Thesis, Free University Amsterdam.

Thesis on the tolerances of salt marsh plant species to salinity, inundation and drought.

231 (1984) Henriksen K., A. Jensen & M.B. Rasmussen

Aspects of nitrogen and phosphorus mineralization and recycling in the northern part of the Danish Wadden Sea.
Neth. Inst. Sea Res. Publ. Ser. 10:51-69.

A complete N and P cycle of a small intertidal basin in Denmark

232 (1985) King D. & D.B. Nedwell

The influence of nitrate concentration upon the end-products of nitrate dissimilation by bacteria in anaerobic salt marsh sediment.
FEMS Microbiol. Ecol. 31:23-28.

Experiments with slurries of salt marsh sediments, indicating the high denitrification potential when nitrate or nitrite is available, especially under anaerobic conditions.

233 (1979) Wainwright M.

Enzyme activity in intertidal sands and salt-marsh soils.
Plant Soil 59:357-363.

Measurement of arylsulphate, cellulase and rhodanese activities close to salt marsh plant roots.

234 (1985) Armstrong W., E.J. Wright, S. Lythe & T.J. Gaynard

Plant zonation and the effects of the spring-neap tidal cycle on soil aeration in a Humber salt marsh.
J. Ecol. 73:323-339.

Standard work on soil aeration and redox potential of salt marsh soils along a tidal gradient.

235 (1993) Alkemade R., A. Wielemaker & M.A. Hemminga

Correlation between nematode abundance and decomposition rate of Spartina anglica leaves.
Mar. Ecol. Prog. Ser. 99:293-300.

Field studies on the presence of nematodes in decomposed Spartina litter. It is suggested that nematods may enhance microbial decomposition rates.

236 (1974) Grosse-Brauckmann G.

Zum Verlauf der Verlandung bei einem eutrophen Flachsee (nach quartärbotanischen Untersuchungen am Steinhuder Meer). I. Heutige Vegetationszonierung, torfbildende Pflanzengesellschaften der Vergangenheit. [On the course of filling-in by vegetation of an eutrophic shallow lake (results of quaternary botanical investigations at the Lake Steinhuder Meer, North Western Germany). I. Present zonation of vegetation, peat-forming plant communities of the past.]
Flora 163:179-229. (in German, English abstract)

Mires at a shore of a lake correspond very well to the sequence of the 'hydroserie'. The question how the present zonation corresponds to the 'terrestrialisation' in the past is answered by analysis of a number of peat profiles.

237 (1977) Tirén T.

Denitrification in sediment-water systems of various types of lakes.
In: H.L. Golterman (ed.), Interactions between sediments and freshwater. Dr. W. Junk Publishers, The Hague - Pudoc, Wageningen. pp. 363-369.

With the use of a bell jar, NO3-N and O2 consumption, NH4-N release and N2 formation rate were measured in two eutrophic lakes, one unpolluted eutrophic lake canal, one oligotrophic lake in situ. The two eutrophic lakes have much higher denitrification rates.

238 (1988) Armstrong J., W. Armstrong & P.M. Beckett

Phragmites australis: a critical appraisal of the ventilating pressure concept and an analysis of resistance to pressurized gas flow and gaseous diffussion in horizontal rhizomes.
New Phytol. 110:383-389.

Determination of the critical ventilation pressure (in Phragmites australis). This field approach is compared with a theoretical approach. The critical ventilation pressure appeared to be higher in the nodal pith than in the internodal pith.

239 (1976) Grosse-Brauckmann G.

Zum Verlauf der Verlandung bei einem eutrophen Flachsee (nach quartärbotanischen Untersuchungen am Steinhuder Meer). II. Die Sukzessionen, ihr Ablauf und ihre Bedingungen. [On the course of filling-in by vegetation of an eutrophic shallow lake (results of quaternary botanical investigations at the Lake Steinhuder Meer, North Western Germany). II. The succession, course and conditions.]
Flora 165:415-455. (in German, English abstract)

Description and causes of the development of a coastal zone of a shallow lake, studying the vegetative succession.

240 (1988) Iremonger S.F. & D.L. Kelly

The responses of four Irish wetland tree species to raised soil water levels.
New Phytol. 109:491-497.

Seedlings of three Irish wetland tree species were subjected to different soil water levels. Tolerant species were able to oxygenize the soil.

241 (1977) Andersen J.M.

Importance of the denitrification process for the rate of degradation of organic matter in lake sediments.
In: H.L. Golterman (ed.), Interactions between sediments and freshwater. Dr. W. Junk Publishers, The Hague - Pudoc, Wageningen. pp. 357-362.

A correlation between denitrification and O2 consumption is being sought. Denitrification appeared to stimulate degradation of organic matter.

242 (1990) Arts G.H.P., G. van der Velde, J.G.M. Roelofs & C.A.M. van der Swaay

Successional changes in the soft-water macrophyte vegetation of (sub)atlantic, sandy, lowland regions during this century.
Freshwater Biol. 24:287-294.

Changes in nutrient status (N, P and C) and accumulation of organic material can be regarded as the operative factors in recent changes in the aquatic macrophyte vegetation in originally softwaters.

243 (1990) Arts G.H.P., J.G.M. Roelofs & M.J.H. De Lyon

Differential tolerances among soft-water macrophyte species to acidification.
Can. J. Bot. 68:2127-2134.

26 Macrophyte species were studied for their degree of tolerance to extremely acidic conditions

244 (1977) Jorgensen S.E.

The influence of phosphate and nitrogen in sediment on restoration of lakes.
In: H.L. Golterman (ed.), Interactions between sediments and freshwater. Dr. W. Junk Publishers, The Hague - Pudoc, Wageningen. pp. 387-389.

Model predicting production and transparency of a lake by changed P-loadings considering mud-water interaction processes.

245 (1977) Ahlgren I.

Role of sediments in the process of recovery of a eutrophicated lake.
In: H.L. Golterman (ed.), Interactions between sediments and freshwater. Dr. W. Junk Publishers, The Hague - Pudoc, Wageningen. pp. 372-377.

Phosphorus release rates and accumulation in the sediment of formerly eutrophicated lake were not changed during the process of lake recovery

246 (1972) Waughman G.J. & D.J. Bellamy

Potential nitrogen fixation on some European peatlands.
In: Proceedings of the 4th international peat congress, Finland, 1972. Vol. 1. Virgin peatlands. Conservation, terminology. pp. 309-318.

Acetylene reduction (indication of N2-fixation) was observed in mires with pH 4.5-8. Acetylene reduction increases in the later part of the year (dying-back of vegetation), and decreases at pH <5. Includes review of N2-fixation by other workers.

247 (1977) Kamp-Nielsen L.

Modelling the temporal variation in sedimentary phosphorus fractions.
In: H.L. Golterman (ed.), Interactions between sediments and freshwater. Dr. W. Junk Publishers, The Hague - Pudoc, Wageningen. pp. 277-285.

The temporal variation in sedimentation and sedimentary phosphorous fractions (total P, exchangeable P, extractable P) ware measured in lake sediments at different depths. A model was constructed simulating sedimentary P fractions as function of sedimentation, water P concentrations, Temperature and O2 concentrations.

248 (1979) Abdollahi H. & D.B. Nedwell

Seasonal temperature as a factor influencing bacterial sulfate reduction in a saltmarsh environment.
Microbial Ecol. 5:73-79.

The sulphate reduction rate in a saltmarsh is related to temperature by an Arrhenius function. The temperature characteristics of the population of sulphate-reducing bacteria did not significantly with season, indicating no adaptation of the population to seasonally changing temperature

249 (1977) Stevens R.J. & C.E. Gibson

Sediment release of phosphorus in Lough Neagh, Northern Ireland.
In: H.L. Golterman (ed.), Interactions between sediments and freshwater. Dr. W. Junk Publishers, The Hague - Pudoc, Wageningen. pp. 343-347.

A phosphorus input-output budget was calculated for Lough Neagh. During summer, high amounts of P were released from the sediment when the water overlying the sediment was oxygen depleted, but not anoxic.

250 (1977) Jorgensen B.B.

The sulfur cycle of a coastal marine sediment (Limfjorden, Denmark).
Limnol. Oceanogr. 22:814-832.

The cyclic transformation of inorganic sulphur compounds in the sediments if the Danish Limfjorden were followed during 2 years. A budget was calculated from measured sulphate reduction rates and determination of various sulphur compounds. Sulphate reduction accounted for 53% of the total mineralization of organic matter in the sediment.

251 (1977) Golterman H.L.

Sediments as a source of phosphate for algal growth.
In: H.L. Golterman (ed.), Interactions between sediments and freshwater. Dr. W. Junk Publishers, The Hague - Pudoc, Wageningen. pp. 286-293.

Accumulated phosphates in bottom sediments of shallow lakes might become a major source for algal growth if future phosphate loadings will be restricted. Extraction of P from the sediment with NaNTA induced algal blooms in a pond with phosphate poor ground water.

252 (1992) Jauhiainen J., H. Vasander & J. Silvola

Differences in response of two Sphagnum species to elevated CO2 and nitrogen input.
Suo 43:211-215.

Higher CO2 levels increased shoot density, but decreased shoot-length.

253 (1992) Lien T., P. Martikainen, H. Nykänen & L. Bakken

Methane oxidation and methane fluxes in two drained peat soils.
Suo 43:231-236.

Methane production (lab and field) and methane oxidation (lab) was measured in samples in samples of minerotrophic and ombrothrophic peat. Fluxes and oxidation were higher in ombrothrophic peat.

254 (1993) Otte M.L., M.S. Haarsma, R.A. Broekman & J. Rozema

Relation between heavy metal concentrations in salt marsh plants and soil.
Environ. Pollut. 82:13-22.

The relation between various extractable fractions of metals in salt marsh sediments and metal accumulation in salt marsh plants has been studied in samples taken from salt marshes in the Netherlands. the correlation of accumulated metals with various fractions (water, acetate and DPTA extraction's) of metals present in soils were not better than correlation's with the total metal content in soils.

255 (1993) Lefeuvre J.C., N. Dankers, L. Boorman, P. Loveland & A. Bettencourt

Comparative study on salt marsh processess. Final report - Volume 1.
EEC Contract EV4V-0172-F (EDB). 258 pp.

A comparative study on primary production processes at four European salt marshes (Netherlands, France, England, Portugal) and the nutrient exchanges of these salt marshes with the marine environment. New methods are applied to confirm estimates of organic matter transformation and nutrient fluxes in salt marsh soils.

256 (1984) Reinikainen A., T. Lindholm & H. Vasander

Ecological variation of mire site types in the small kettle-hole mire Heinisuno, southern Finland.
Ann. Bot. Fennici 21:79-101.

Fifteen different mire types were analysed on water table, thickness of the aerobic peat layer, surface water tension and peat and water chemistry. Three different groups could be

distinguished. vegetation and site-type change along a complex gradient, involving water level, water level fluctuations, and nutrient regime.

257 (1993) Reboredo F.

How differences in the field influence Cu, Fe and Zn uptake by Halimione portulacoides and Spartina maritima.
Sci. Total Environ. 133:111-132.

Strong accumulation of metals in roots is observed, compared to leaves. accumulation of metals is reduced under waterlogged conditions. There are also observations made on the accumulation of metals in soils due to deposition of dead leaves.

258 (1986) Abd.Aziz S.A. & D.B. Nedwell

The nitrogen cycle of an east coast, U.K. saltmarsh: II. Nitrogen fixation, denitrification, tidal exchange.
Est. Coast. Shelf Sci. 22:689-704.

Cyanobacteria stimulate the nitrogen fixation in salt marshes soils. Shading by mergent plants reduces the nitrogen fixation rates. Only a small part of the decomposed organic matter has been transformed into nitrate. Denitrification is limited by nitrate. No exchange of N with tides has been observed.

259 (1980) Markstein B. & H. Sukopp

Die Ufervegetation der Berliner Havel 1962-77. [The waterside vegetation of the Berlin Havel 1962-77.]
Garten + Landschaft 1/80:30-36. (in German and English)

Changes in the vegetation bordering a lake in Germany

260 (1978) Kowalczewski A.

Importance of a bordering wetland for chemical properties of lake water.
Verh. Int. Ver. Limnol. 20:2182-2185.

A description of the carbon cycle in a small pond showing DOC production in the swamp due to decomposition.

261 (1980) Linden M.J.H.A. van der

Nitrogen economy of reed vegetation in the Zuidelijk Flevoland polder. I. Distribution of nitrogen among shoots and rhizomes during the growing season and loss of nitrogen due to fire management.
Acta Oecol. Oecol. Plant. 1:219-230.

A field study indicating the importance of internal recirculation of N in reed stands: allocation in roots during winter and reallocation in shoots during the summer.

262 (1992) Kühl H. & J.G. Kohl

Nitrogen accumulation, productivity and stability of reed stands (Phragmites australis (Cav.) Trin. ex Steudel) at different lakes and sites of the Lake District of Uckermark and Mark Brandenburg (Germany).
Int. Rev. Ges. Hydrobiol. 77:85-107.

Study on the allocation of nitrogen in reed stands in reference to nitrogen availability in sediments and surface waters.

263 (1988) Lee J.A. & S.J. Woodin

Vegetation structure and the interception of acidic deposition by ombotrophic mires.
In: J.T.A. Verhoeven, G.W. Heil & M.J.A. Werger (eds.), Vegetation structure in relation to carbon and nutrient economy. SPB Academic Publishing, The Hague. pp. 137-147.

The importance of Sphagnum species as interceptor of acidic deposition (emphasis on nitrate ions)

264 (1991) Velimirov B.

Detritus and the concept of non-predatory loss.
Arch. Hydrobiol. 121:1-20.

Review of the definitions of 'detritus', and proposal of a definition for detritus, based on the concept of 'non-predatory loss'.

265 (1987) Bakker J.P., C. Brouwer, L. van den Hof & A. Jansen

Vegetational succession, management and hydrology in a brookland (the Netherlands).
Acta Bot. Neerl. 36:39-58.

Vegetational succession, management and hydrology in a brookland. Distribution of watertypes by indicative plant species.

266 (1990) Rijs G.B.J.

Toepassing van helofytenfilters in de afvalwaterzuivering. [Application of wetland systems for wastewater treatment.]
The Utrecht Plant Ecology News Report 11:147-166. (in Dutch, English summary)

Technical report concerning the application of wetland systems for wastewater treatment.

267 (1985) Maeseneer J. de

Afvalwaterzuivering met kunstmatige rietvelden in België. [Wastewater treatment with artificial reed marshes in Belgium.]
The Utrecht Plant Ecology News Report 4:141-148. (in Dutch, English Abstract)

Development of wastewater treatment plants for purification of wastewater.

268 (1985) Butijn G.D. & R.W. Greiner

Afvalwaterzuivering met behulp van begroeide infiltratievelden. [Wastewater treatment with vegetated percolation fields.]
The Utrecht Plant Ecology News Report 4:64-90. (in Dutch, English Abstract)

Processes and application of wastewater treatment with vegetated percolation fields.

269 (1985) Greiner R.W. & G.D. Butijn

Afvalwaterzuivering met behulp van begroeide vloeivelden. [Wastewater treatment with vegetated irrigation fields.]
The Utrecht Plant Ecology News Report 4:39-63. (in Dutch, English Abstract)

Processes and application of wastewater treatment with vegetated irrigation fields. Data are represented from the first experimental field. Economic aspects also included.

270 (1990) Duel H.

Onderzoeksprogramma over de toepassing van helofytrenfilters voor kwaliteitsverbetering van het oppervlaktewater in het landelijk gebied. [Research needs on the use of wetlands for improvement of surfacewater quality in rural areas.]
The Utrecht Plant Ecology News Report 11:188-202. (in Dutch, English summary)

Article describing the research needs on use of wetlands for improvement of surfacewater quality in rural areas.

271 (1990) Meuleman A.F.M.

Zuiveringsmoerassen ten behoeve van de natuurbescherming. [Wetlands for water treatment in nature conservation.]
The Utrecht Plant Ecology News Report 11:167-187. (in Dutch, English summary)

Describes the development of a wetland used for purification and nature conservation.

272 (1990) Fiselier J.L.

Moerassystemen in perspectief. [Wetland systems in perspective.]
The Utrecht Plant Ecology News Report 11:225-246. (in Dutch, English summary)

General 'review' about processes andmanagement of wetland systems used for purification of wastewater.

273 (1990) Kappe L.J.

Rentabiliteit van riet- en biezenvelden als zuiveringssystemen. [Financial viability of reed- and bulrush-fields as water treatment systems.]
The Utrecht Plant Ecology News Report 11:204-224. (in Dutch, English summary)

The financial viability of reed- and bulrush-fields as water treatment systems is discussed.

274 (1975) Granhall U. & V. Lid-Torsvik

Nitrogen fixation by bacteria and free-living blue-green algae in tundra soils.
In: F.E. Wielgolaski (ed.), Fennoscandian Tundra Ecosystems. Part 1. Plants and microorganisms. Springer-Verlag. pp. 305-315.

Measurements of nitrogen fixation in Scandinavian tundra soils, being main nitrogen source.

275 (1984) Pieczynska E., D. Balcerzak, A. Kolodziejczyk, Z. Olszewski & J.I. Rybak

Detritus in the littoral of several Masurian lakes (sources and fate).
Ekol. Pol. 32:387-440.

Origin, quantity and chemical composition of detritus were determined in the littoral of five lakes in Poland.

276 (1992) Karman C.C.

Mariene helofytenfilters.
Report Free University, Amsterdam. (in Dutch)

Mesocosm study on the suitability of salt marshes for purification of wastewater (enriched with N)

277 (1992) Leendertse P.C.

Vegetatie-ontwikkeling op de Boschplaat van Terschelling tussen 1953 en 1990 in relatie tot stikstofgehalten in de bodem.
Report Free University, Amsterdam. (in Dutch)

Development of vegetation on the Boschplaat (NL) related to nitrogen concentrations in soil.

278 (1992) Leendertse P., C.C. Karman & J. Rozema

Zoete en zoute helofytenfilters langs de Afsluitdijk - een haalbaarheidsstudie.
Report Free University, Amsterdam. (in Dutch)

A feasability study of the development of salt- and freshwater wetlands for the purification of water from lake IJsselmeer (NL).

279 (1985) Gudde L., A. Kooijman, J.T.A. Verhoeven & G. van Wirdum

Onderzoek naar de nutriëntenhuishouding van een trilveen in de 'Weerribben'. [Study of nutrient dynamics of a quaking fen in 'De Weerribben'.]
The Utrecht Plant Ecology News Report 2:46-52. (in Dutch, English abstract)

Study of nutrient dynamics of a quaking fen.

280 (1982) Sarvala J., T. Kairesalo, I. Koskimies, A. Lehtovaara, J. Ruuhijärvi & I. Vähä-Piikkio

Carbon, phosphorus and nitrogen budgets of the littoral *Equisetum* belt in an oligotrophic lake.
Hydrobiologia 86:41-53.

C, P and N budgets for a littoral Equisetum-stand in an oligotrophic Finnish lake.

281 (1976) Granhall U. & A.V. Hofsten

Nitrogenase activity in relation to intracellular organisms in *Sphagnum* mosses.
Physiol. Plant. 36:88-94.

Intracellular organisms (blue green algae, green algae, bacteria and fungi) are present in Sphagnum species. Nitrogenase activity of Sphagnum was found to be related to intracellular Nostoc filaments.

282 (1965) Clymo R.S.

Experiments on breakdown of Sphagnum in two bogs.
J. Ecol. 53:747-757.

Experiments on the break-down rates of different Sphagnum species, at different depths in peat bogs. Experiments on the loss-rates of the various chemical constituents of Sphagnum.

283 (1989) Menendez M., E. Forés & F.A. Comin

Ruppia cirrhosa - Decomposition in a coastal temperate lagoon as affected by macroinvertebrates.
Arch. Hydrobiol. 117:39-48.

Rates of decomposition of Ruppia cirrhosa by macrofauna < 1mm and < 0.1mm.

284 (1991) Ambus P. & R. Lowrance

Comparison of denitrification in two riparian soils.
Soil Sci. Soc. Am. J. 55:994-997.

Denitrification in surface soil and shallow aquifer samples of two riparian soils was measured, after addition of distilled water, NO3-N, glucose-C or NO3+ glucose.

285 (1985) Grootjans A.P., P.C. Schipper & H.J. van der Windt

Influence of drainage on N-mineralization and vegetation response in wet meadows. I. *Calthion palustris* stands.
Acta oecol. Oecol. Plant. 6:403-417.

Lowering of the groundwater table in a hay-meadow resulted in increased net N-mineralization (5-10 fold), increased vegetation yields, expansion of nitrophilous herbs and drop in pecies richness. Undrained parts of the meadow showed an increase in ammonification under very wet conditions.

286 (1993) Mountford J.O. & J.M. Chapman

Water regime requirements of British wetland vegetation: Using the moisture classifications of Ellenberg and Londo.
J. Environ. Manage. 38:275-288.

English grazing marsh ditches and wet grasslands vegetations were characterized by Ellenberg and Londo indicator values, with resoect to water-regime requirements.

287 (1991) Janiesch P.

Ecophysiological adaptations of higher plants in natural communities to waterlogging.
In: J. Rozema & J.A.C. Verkleij (eds.), Ecological responses to environmental stresses. Kluwer Academic Publishers, Dordrecht. pp. 50-60.

Review on ecophysiological tolerance of higher plants against soil conditions related to waterlogging, viz. iron and manganese toxicity. It is stressed that metabolic adaptations are of minor importance compared to root porosity, radial oxygen loss and iron tolerance

288 (1994) Scholten M.C.Th., P.C. Leendertse, L. van der Vlies, J.T. van der Wal, H.P.M. Schobben, R.A. Broekman & J. Rozema

The fate and effects of nutrients and contaminants in a salt marsh ecosystem. A mesocosm study: SMEX I.
TNO report R94/073.

Long term mesocosm study on the fate of contaminants and nutrient in salt marsh ecosystems. It is demonstrated that salt marsh sediment can act as a sink for contaminations and nutrients, except for remobilization due to resuspension.

289 (1994) Scholten M.C.Th., R.G. Jak, B. Pavoni, A. Sfriso, C.J.M. Philippart, N. Dankers, H. de Heij & W. Helder

BEST. Benthic Eutrophication Studies. Synthesis report.
TNO report R94/049.

A mesocosm study and related field study (Venice Lagoon) on the exchange of nutrients between water and sediment, and the environmental consequences of progressive fertilisation of shallow coastal waters.

290 (1989) Strien A.J. van, J. van der Linden, Th.C.P. Melman & M.A.W. Noordervliet

Factors affecting the vegetation of ditch banks in peat areas in the western Netherlands.
J. Appl. Ecol. 26:989-1004.

The effect on a number of environmental factors on the floristic richness of ditch banks vegetation in peat areas were studied to find the best management strategy for conservation.

291 (1985) Malmer N.

Remarks to the classification of mires and mire vegetation - Scandinavian arguments.
Aquilo Ser. Bot. 21:9-17.

Floristically characterised gradients are recognised in the NW European mire vegetation, which, however, not always follow the variation described by the hydrotopographical mire types.

292 (1988) Gunatilaka A.

Estimation of the available P-pool in a large freshwater marsh.
Arch. Hydrobiol. Beih. Ergebn. Limnol. 30:15-24.

In summer the P-pool size in a reed marsh decreased to depleted levels as a result of the high P-demand of the Phragmites australis during the growing period.

293 (1988) Beltman B. & J.T.A. Verhoeven

Distribution of fen plant communities in relation to hydrochemical characteristics in the Vechtplassen area, the Netherlands.
In: J.T.A. Verhoeven, G.W. Heil & M.J.A. Werger (eds.), Vegetation structure in relation to carbon and nutrient economy. SPB Academic Publishing, The Hague. pp. 121-135.

Distributions patterns of plant communities in small fens and hayfields are compared to the spatial patterns of hydrogeochemical characteristics in the Vechtplassen area, The Netherlands.

294 (1994) Rysgaard S., N. Risgaard-Petersen, N.P. Sloth, K. Jensen & L.P. Nielsen

Oxygen regulation of nitrification and denitrification in sediments.
Limnol. Oceanogr. 39:1643-1652.

Oxygen regulate nitrification and denitrification in sediments: Flow-through experiments with constant NO3 and varying O2 showed an increase of the nitrification at increasing O2 (0-100% saturation), and only a slight increase above 100%. The N-source for denitrification is NO3 from the overlying water at 100%, and NO3 produced by nitrification at O2 > 100%. This has environmental implications.

295 (1978) Basilier K., U. Granhall & T.A. Stenström

Nitrogen fixation in wet minerotrophic moss communities of a subarctic mire.
Oikos 31:236-246.

Nitrogen fixation by bleu-green algae associated with mosses is found to be higher at the periphery of the moss vegetation due to the best light conditions. The pH does not influence nitrogen fixation.

296 (1975) Svensson B.H., A.K. Veum & S. Kjelvik

Carbon losses from tundra soils.
In: F.E. Wielgolaski (ed.), Fennoscandian Tundra Ecosystems. Part 1. Plants and microorganisms. Springer-Verlag. pp. 279-286.

Measurements of gaseous carbon losses (CO2 and CH4) at Norwegian and Swedish tundra sites, in order to estimate mineralisation rates. Carbon losses are compared with C-fixation in primary production.

297 (1982) Boström B., M. Jansson & C. Forsberg

Phosphorus release from lake sediments.
Arch. Hydrobiol. Beih. Ergebn. Limnol. 18:5-59.

Review on factors and processes which govern phosphorous release from Lake sediments. Processes are affected by a number of environmental factors, of which redox potential, pH and temperature are most important.

298 (1985) Verhoeven J.T.A.

Mineralisatie van N en P in de bodem van twee voedselarme en twee voedselrijke trilvenen.
[Mineralisation of N and P in the soils of two nutrient-poor and two nutrient-rich fens.]
The Utrecht Plant Ecology News Report 2:64-70. (in Dutch, English abstract)

Incubation experiments were carried out in two mesotrophic and two eutrophic fens to determine the mineralization rates of N and P in organic peat soils with respect to the nutrient supply to the vegetation.

299 (1944) Mattson S., G. Sandberg & P.E. Terning

Electro-chemistry of soil formation. VI. Atmospheric salts in relation to soil and peat formation and plant composition.
Kungl. Landbrukshögsk. Ann. 12:101-118. [Ann. Agric. Coll. Sweden]

Because of the differences between oceanic/atmospheric salt (Ca/Mg » 0.2) and soil solution/river salt (Ca/Mg >1), ombrogenic formations (raised bogs) differ in salt composition from other formations. In a field survey Ca/Mg in different soils and plants were determined.

300 (1985) Vermeer H.J.G. & J.T.A. Verhoeven

Soortensamenstelling en biomassa produktie van plantengemeenschappen van mesotrofe trilveen systemen in relatie tot hun nutrientenhuishouding. [Species composition and biomass production of plant communities of mesotrophic fen systems in relation to their nutrient dynamics.]
The Utrecht Plant Ecology News Report 2:8-17. (in Dutch, English abstract)

Three main groups of fen plants could be distinguised in a survey on the species composition and aerial biomass productions of plant communities in oligotrophic and mesotrophic fen systems (Vechtplassen-area, the Netherlands). Nutrient concentrations in plant and soil were measured and used to calculate correlation's.

301 (1976) Pietsch W.

On the relation between the vegetation and the absolute and relative ion content of mire waters in middle Europe.
In: Proceedings of the 5th international peat congress, Poznan, Poland. pp. 62-72.

On the basis of the absolute ion content and the relative ionic composition of 64 different mire waters in middle Europe, the investigated 490 bog vegetation complexes were divided into 6 groups.

302 (1994) Freeman C., J. Hudson, M.A. Lock, B. Reynolds & C. Swanson

A possible role of sulphate in the suppression of wetland methane fluxes following drought.
Soil. Biol. Biochem. 26:1439-1442.

The possible role of sulphate in the suppression of wetland methane fluxes following drought was investigated in the field (peat-accumulating freshwater wetlands).

303 (1990) Malmer N.

Constant or increasing nitrogen concentrations in Sphagnum mosses on mires in southern Sweden during the last few decades.
Aquilo Ser. Bot. 28:57-65.

Although increased atmospheric deposition of N and S has occurred during the last few decades, only minor changes in the concnetration were found in Sphagnum mosses, particularly an increase in P in some of the samples.

304 (1985) Grootjans A.P., P.C. Schipper & H.J. van der Windt

Influence of drainage on N-mineralization and vegetation response in wet meadows. II. Cirsio-Molinietum stands.
Acta oecol. Oecol. Plant. 7:3-14.

Influence of drainage on N-mineralisation and vegetation response in wet meadows. Mineralisation in drained peat was 2-3 times higher then in undrained peat. Plant growth was not liited by nitrogen, but by phosphorus.

305 (1986) Vermeer J.G.

The effect of nutrients on shoot biomass and species composition of wetland and hayfield communities.
Acta Oecol. Oecol. Plant. 7:31-41.

The effect of increased nutrient availability was studied in field experiments in a fen, a wet grassland and a hayfield, with the purpose to find out which nutrients limit growth in these systems. It was found that N and P were the limiting nutrients in the fen and the wet grassland and that K was limiting in the hayfield. In all plants communities a negative relationship between increasing nutrient availability and species diversity was found, maainly due to an increase in some grass species.

306 (1987) Denny P.

Mineral cycling by wetland plants - A review.
Arch. Hydrobiol. Beih. Ergebn. Limnol. 27:1-25.

A basic review on the uptake and cycling of nutrients in wetland plants, categorized as emergent, floating,submerged and floating-leaved plants. This related to production and decomposition of plant material. Special emphasis is given to the coupling of nutrient cycles in sediments or surface dwellers.

307 (1978) Gerlach A.

Zur Bestimmung der Stickstoff-Nettomineralisation in mehr oder minder nassen Böden. [Applicability of the incubation method for the determination of nitrogen net mineralization in wet and moist soils.]
Oecol. Plant. 13:163-174. (in German, English abstract)

Applicability of incubation methods for determination of nitrogen mineralization in moist and wet soils was verified by measuring the nitrogen uptake of a grass species.

308 (1973) Imhof G.

Aspects of energy flow by different food chains in a reed bed. A review.
Pol. Arch. Hydrobiol. 20:165-168.

The primary production of reed marshes is mainly converted to detritophagous animals and microbial decompossition, only a few percentages is used by phytophagous animals.

309 (1988) Alexandrov G.A.

A spatially-distributed model of raised bog relief.
In: W.J. Mitsch, M. Straskraba & S.E. Jorgensen (eds.), Wetland modelling. Developments in Environmental Modelling 12. Elsevier, Amsterdam. pp. 41-53.

A description of a model to simulate raised bog relief. It includes hydrolic conductivity, evapotransportation and peat accumulation.

310 (1988) Logofet D.O. & G.A. Alexandrov

Interference between mosses and trees in the framework of a dynamic model of carbon and nitrogen cycling in a mesotrophic bog ecosystem.
In: W.J. Mitsch, M. Straskraba & S.E. Jorgensen (eds.), Wetland modelling. Developments in Environmental Modelling 12. Elsevier, Amsterdam. pp. 55-66.

Mathemetical model to simulate the interference between mosses and trees. Takes into account carbon and nitrogen cycles.

311 (1988) Jorgensen S.E., C.C. Hoffmann & W.J. Mitsch

Modelling nutrient retention by a reedswamp and wet meadow in Denmark.
In: W.J. Mitsch, M. Straskraba & S.E. Jorgensen (eds.), Wetland modelling. Developments in Environmental Modelling 12. Elsevier, Amsterdam. pp. 133-151.

Description of a model to accumulate the capacity of a reedswamp to purify waste- or surfacewater. Takes into account nutrient dynamics and hydrological processes.

312 (1988) Straskraba M. & P. Mauersberger

Some simulation models for water quality management of shallow lakes and reservoirs and a contribution to ecosystem theory.
In: W.J. Mitsch, M. Straskraba & S.E. Jorgensen (eds.), Wetland modelling. Developments in Environmental Modelling 12. Elsevier, Amsterdam. pp. 153-175.

Description of a very general (i.e. takes into account a large number of state variables) model for water quality mangement. Includes a comparison between a thermodynamic and a cybernetic approach.

313 (1995) Jonsdottir I.S., T.V. Callaghan & J.A. Lee

Fate of added nitrogen in a moss-sedge arctic community and effects of increased nitrogen deposition.
Sci. Total Environ. 160/161:677-685.

Effects of increased N deposition on an arctic two-species plant community adapted to low availability of nutrients.

314 (1995) Kämäri J., M. Posch, A.M. Kähkönen & M. Johansson

Modeling potential long-term responses of a small catchment in Lapland to changes in sulfur deposition.
Sci. Total Environ. 160/161:687-701.

Description of the SMART model, developed to estimate long-term chemical changes in soil and lake water in response to changes in atmospheric deposition.

315 (1995) Sloth N.P., H. Blackburn, L.S. Hansen, N. Risgaard-Petersen & B.A. Lomstein

Nitrogen cycling in sediments with different organic loading.
Mar. Ecol. Prog. Ser. 116:163-170.

Sediment cores from an intertidal marine area were experimentally loaded with different amounts of organic material, in order to investigate regulation of processes in the nitrogen cycle, and the fate of inorganic and organic N release through mineralization. The experiment showed that the moderate loading increased N removal through denitrification, while high loading decreased nitrification.

316 (1994) Pelegri S.P. & T.H. Blackburn

Bioturbation effects of the amphipod Corophium volutator on microbial nitrogen transformations in marine sediments.
Mar. Biol. 121:253-258.

Benthic fluxes of CO_2, O_2, NO_3^- and NH_4^+ were measured in microcosms stocked with varying densities of the marine amphipod Corophium volutator. The presence of C. volutator increased overall mineralization processes due to burrow construction and irrigation.

317 (1960) Zonneveld I.S.

De Brabantse Biesbosch. A study of soil and vegetation of a freshwater tidal flats. Part A:English summary with text figures and tables. Part B: Dutch text. Part C: Appendices
Thesis University of Wageningen, Stiboka Bodemkundige studies No.4

In this work, an attempt is made to give a description of the physical character and genesis of a typically -as well unique in the Netherlands as in Europe- Dutch landscape, and at the same time, to give a description of the past, present and future use made of the landscape by man. The task is approached from the geological, the pedological and the ecological viewpoints. Old and new topographical maps, air photographs, a soil map, soil analyses, a number of deeper soil borings, cross-sections, a vegetation map, vegetation records, analyses and transects comprise the most important data used in this study. The study was carried out during the years 1951-1953, before the tidal regime was cut off because of the Delta works, and the area changed considerably. These days (1994) studies are performed in order to re-establish the tidal regime and restore the unique freshwater tidal wetland in its former state.